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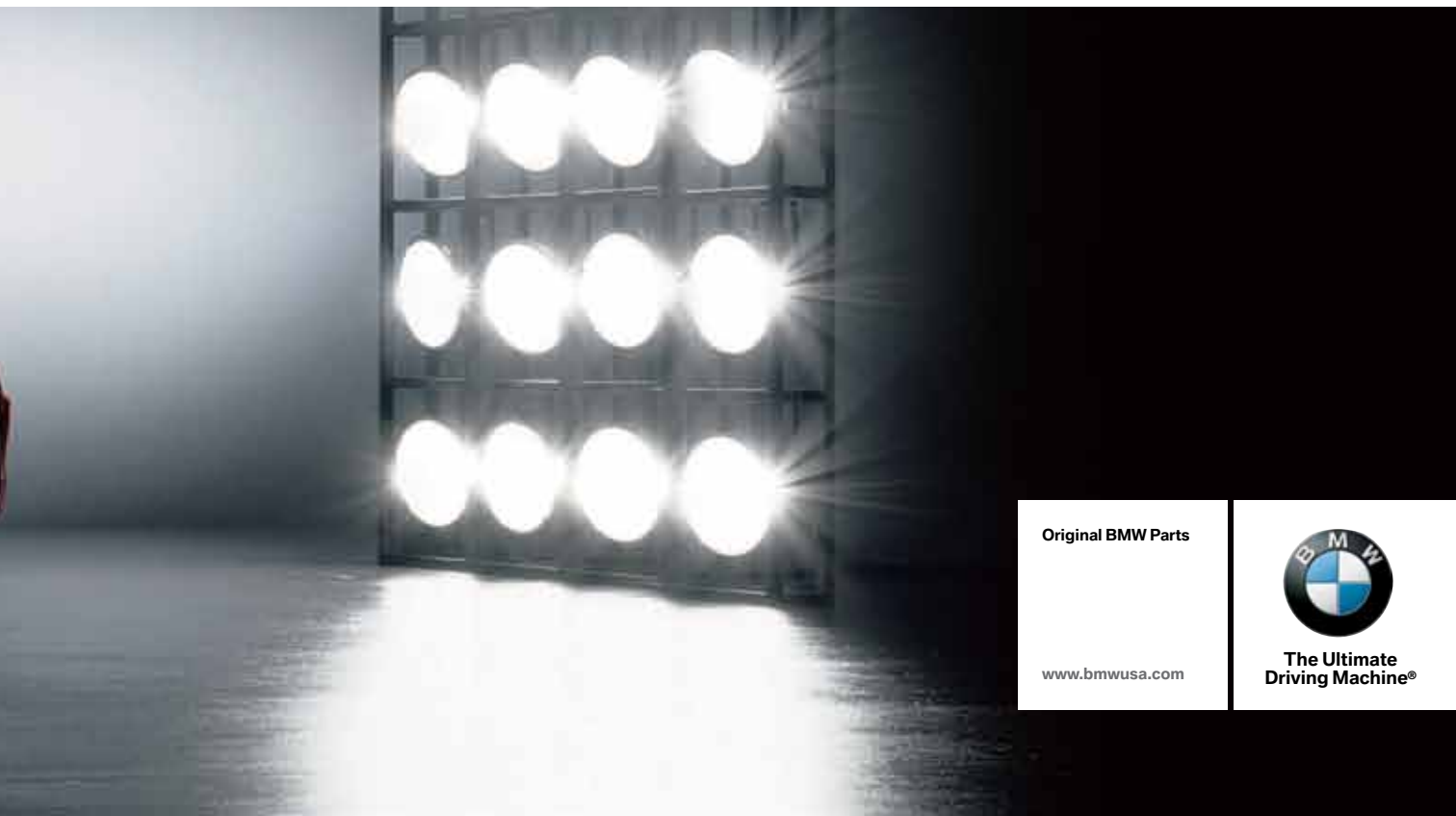

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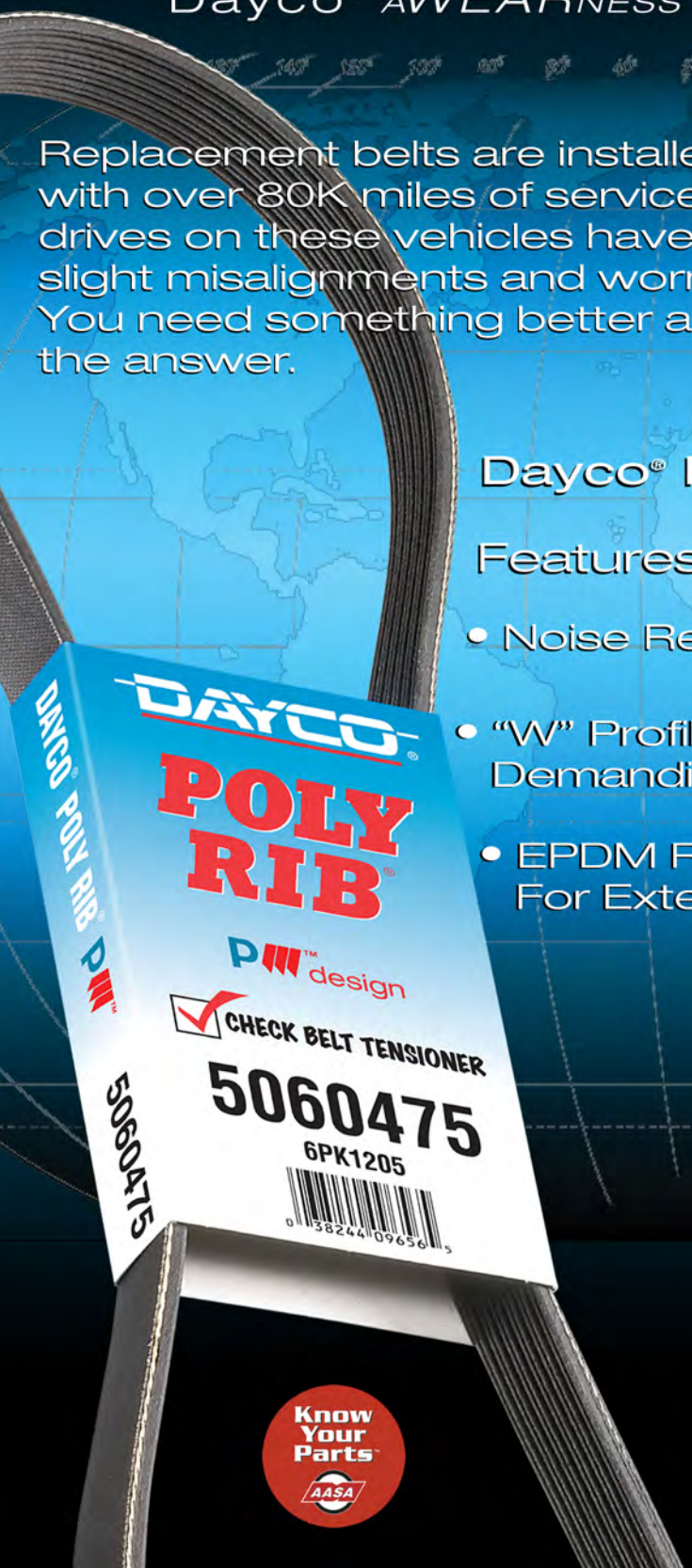

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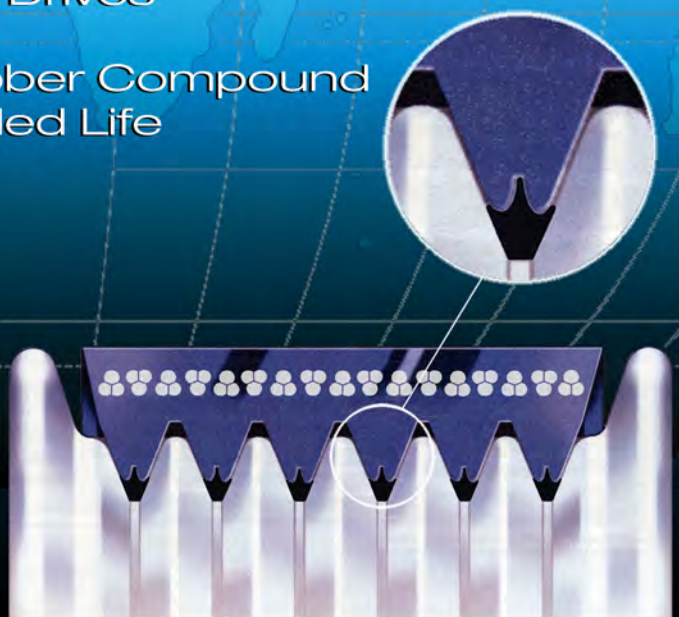

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Christopher M. Ayers, Jr.
President/Publisher: cayers@mastertechmag.com

Bob Freudenberger
Editor: bfreud@mastertechmag.com

John Anello • Steve Campbell • Paul Cortes
Kerry Jonsson • Phil Fournier • Chip Keen
Greg McGoniga • Tony Molla • Tom Nash
Henry Olsen • Matt Ragsdale • Dave Russ
Contributing Editors: bfreud@mastertechmag.com

Christopher-Michael Ayers
Art Director, Project Mgr.: ayersc3@mastertechmag.com

Joann Turner
Circulation Manager: jturner@mastertechmag.com

Editorial, Circulation,
Advertising Sales and Business Office:

Master Technician Magazine
486 Pinecrest Rd. • Springfield, PA • 19064
P.484.472.8441 • F.484.472.7460

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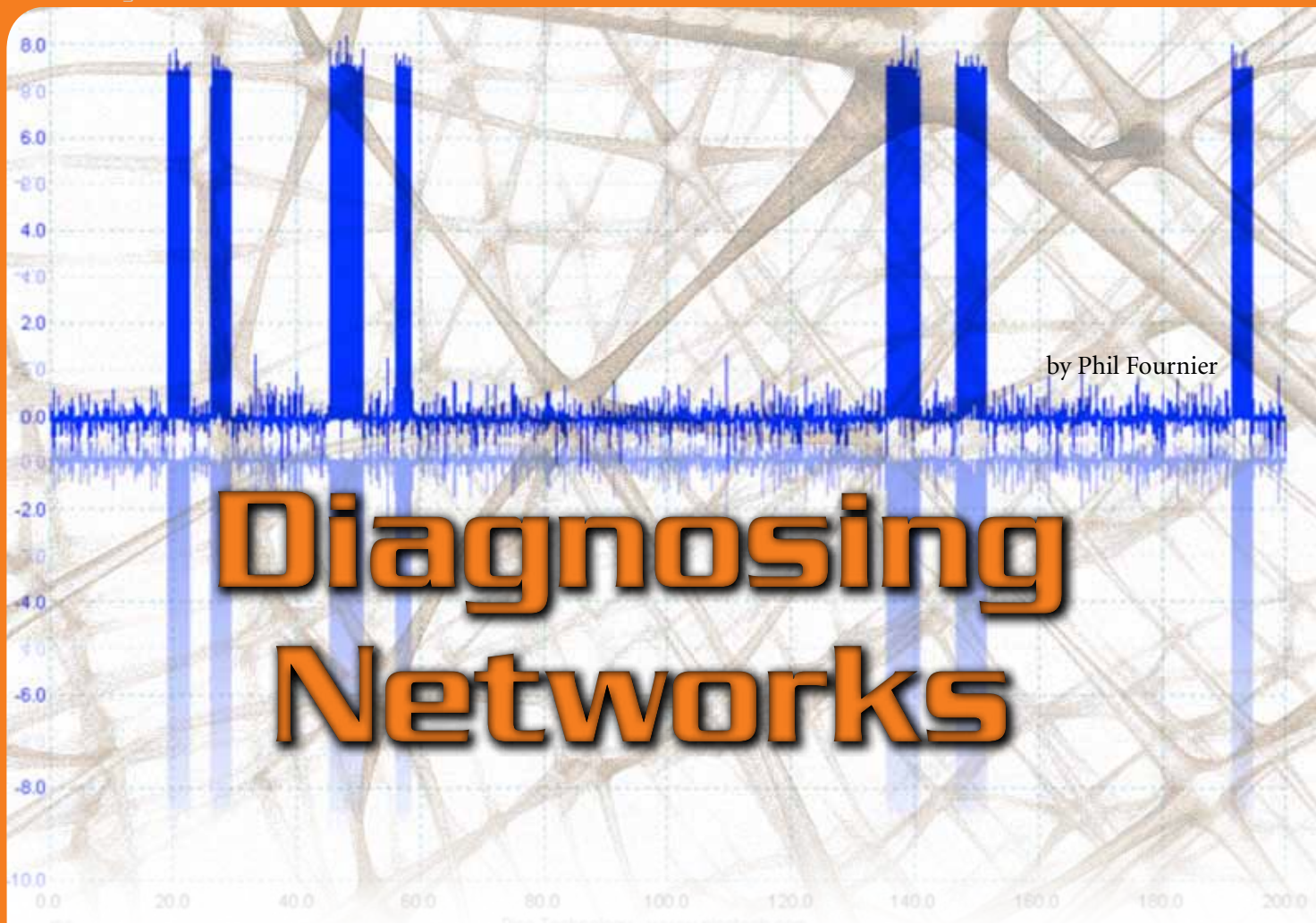


by Phil Fournier

Diagnosing Networks

We technicians learn best by doing, not by reading or listening, or even watching. This makes the automotive instructor's or magazine article author's job a difficult one. But sometimes I read an article or go to a class and come away with a new sense of confidence that I will be able to use the knowledge gained to good effect the next time I am faced with a diagnostic dilemma. I gained just this sense of confidence after attending a Standard Motor Products Network Diagnostic Strategies class. My goal in this article is to see if I can pass along some of that confidence to others trying to learn how to solve a problem of "No Communications," "no bus" or no-start/no-crank issues related to network problems.

Figure 1: AESwave LineSpi

As you probably already know, networks have been with us for 20 years and are with us to stay. I won't bore you with terminology and techno-speak related to networks beyond what is necessary for this article and the one vehicle repair I am going to cover. The vehicle in question was equipped with two networks, a single-wire and a two-wire. It would talk on one of the two networks, and that knowledge is key to doing the diagnosis. Almost all networks report to the DLC for diagnostic purposes and therefore a tool like the LineSpi by AESwave is very useful (*Figure 1*).

Figure 2: 2001 Dodge Durango 4.7L "No Bus"

Our vehicle was a 2001 Dodge Durango with a collection of odd complaints, among which was a dash display that read "no bus" (*Figure 2*)where it should have registered the mileage, dash gauges that usually didn't work, and occasional ringing of the door chime or seat belt chime, even though the doors were closed and the seat belt fastened.

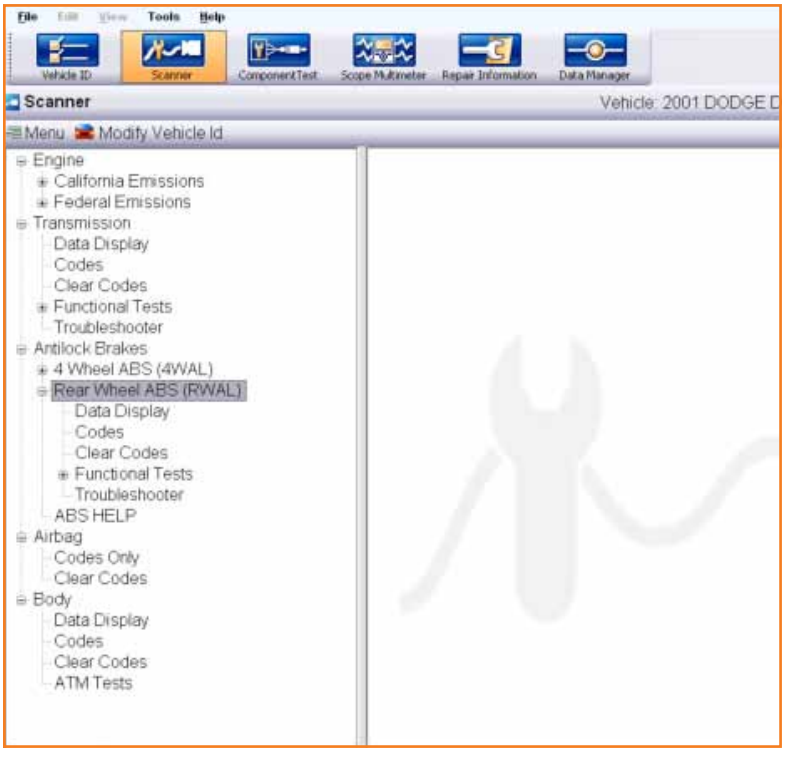


Figure 3: Versus module capability

Naturally, I started my diagnosis with a scan tool. I had on loan a Snap-on Versus scan tool (*Figure 3*) with the latest software, so I thought I would try it first. It auto-identified the vehicle without trouble, which is always an encouraging start. I could not find a function on the tool to scan all modules, so I began checking them one at a time.

I quickly found that I was able to look at all data and codes in the PCM and the TCM. I was unable to look at data in the

ABS module, the Airbag module, and the Body module. But I began to wonder, "Where are the HVAC and MIC (Mechanical Instrument Cluster) modules on the Versus screen?" Since the dash indicated "no bus" and the PRNDL didn't indicate the correct gear, I knew that the MIC was part of the network. I figured I'd better get more information before going forward. I needed to know why I could talk to two modules on the bus without a problem,

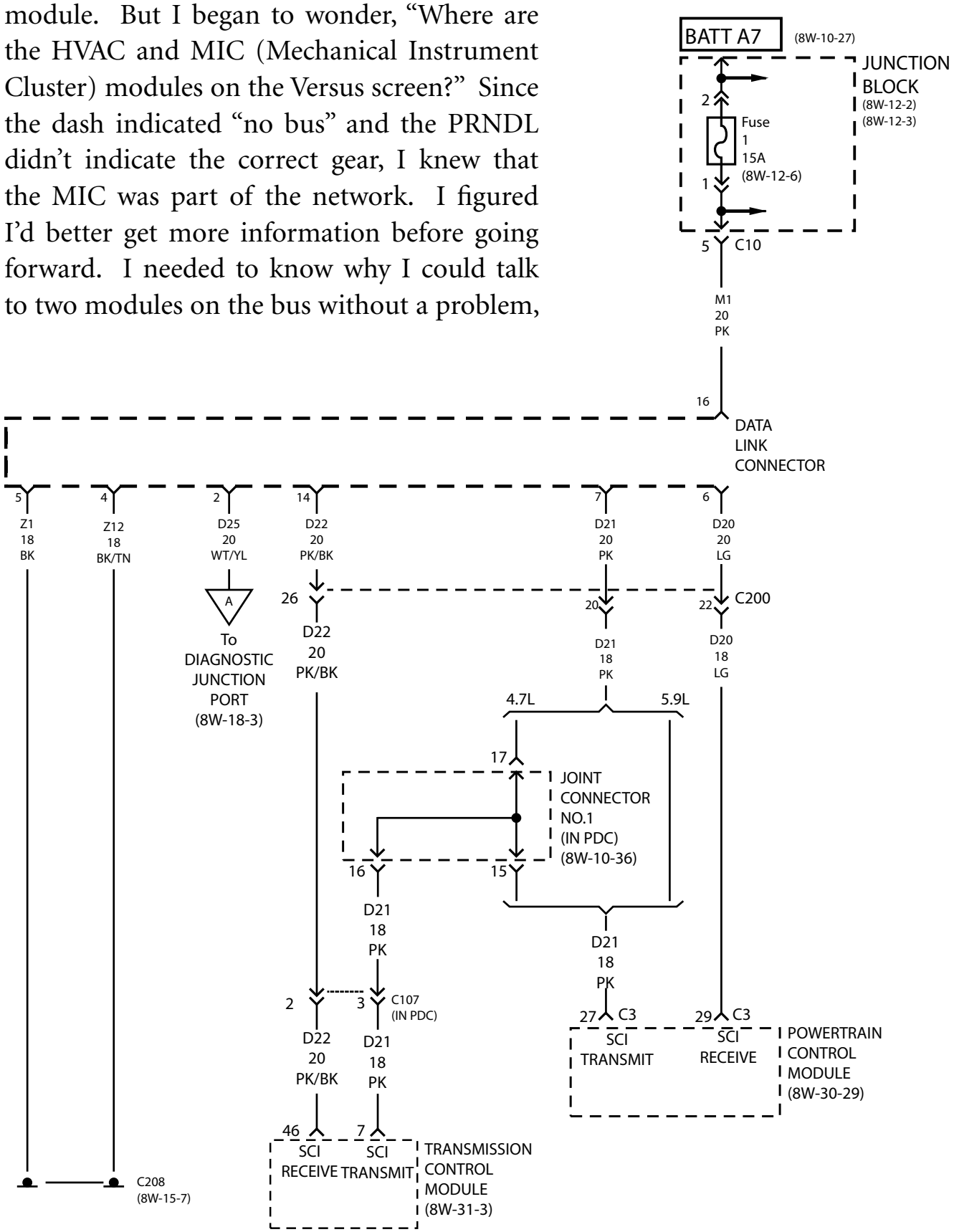
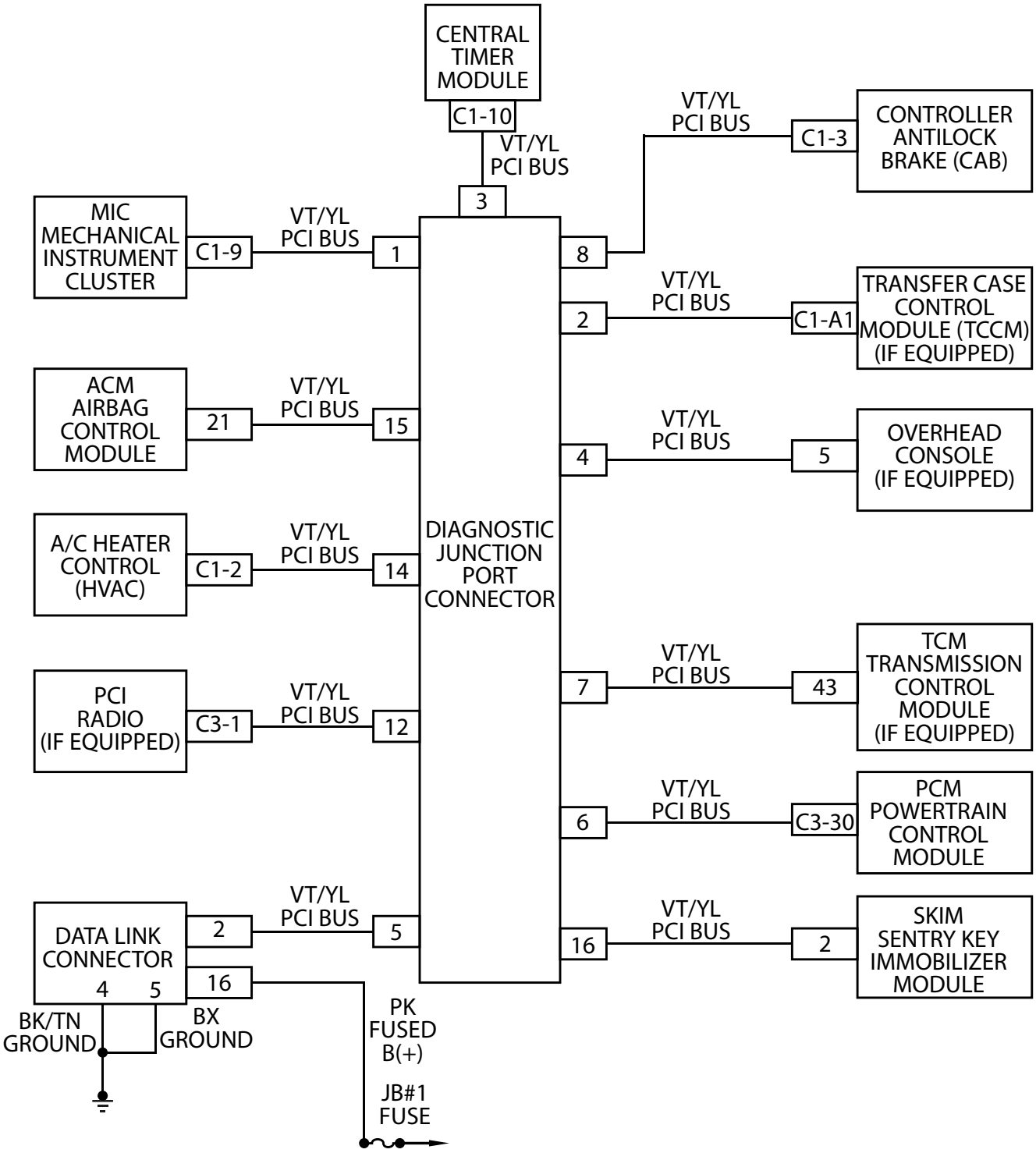


Figure 4 (pg 10 & 11): The SCI and PCI bus connected modules.

but not to three others. I needed to know how many total modules were aboard this vehicle, and how they talk to each other. What "language" do they talk in? I went to my Alldata information system and after entering the vehicle information, I followed this thread: Powertrain Management, Computers and Control Systems, Information Bus (*Figure 4*).



So, this Durango has two information buses. One is an SCI bus and reports to the DLC on pins 6, 7, and 14. Pin 7 is a shared transmit wire for both the PCM and the TCM, while 6 and 14 are the receive wires for the PCM and TCM respectively. But since I could talk to both of these modules, I'm more interested in the other bus, the PCI bus that talks on Pin 2, a single-wire communication network. The other diagram does two things for me: It tells me how many modules may be on the bus (as many as 11), and it tells me that I have a Diagnostic Junction Port Connector. Having a central location where most or all of the single-wire bus signals intersect is a huge benefit -- I have lucked out on this vehicle. (By the way, many GM vehicles use a similar device known as a splice pack.)

But the Versus was only showing me five modules; how many are actually present? Well, this Durango is a stripped model -- two-wheel drive, and not equipped with an Immobilizer (SKIM), overhead console, or the upgraded radio, so I could eliminate those modules (the Central Timer Module is Chrysler's

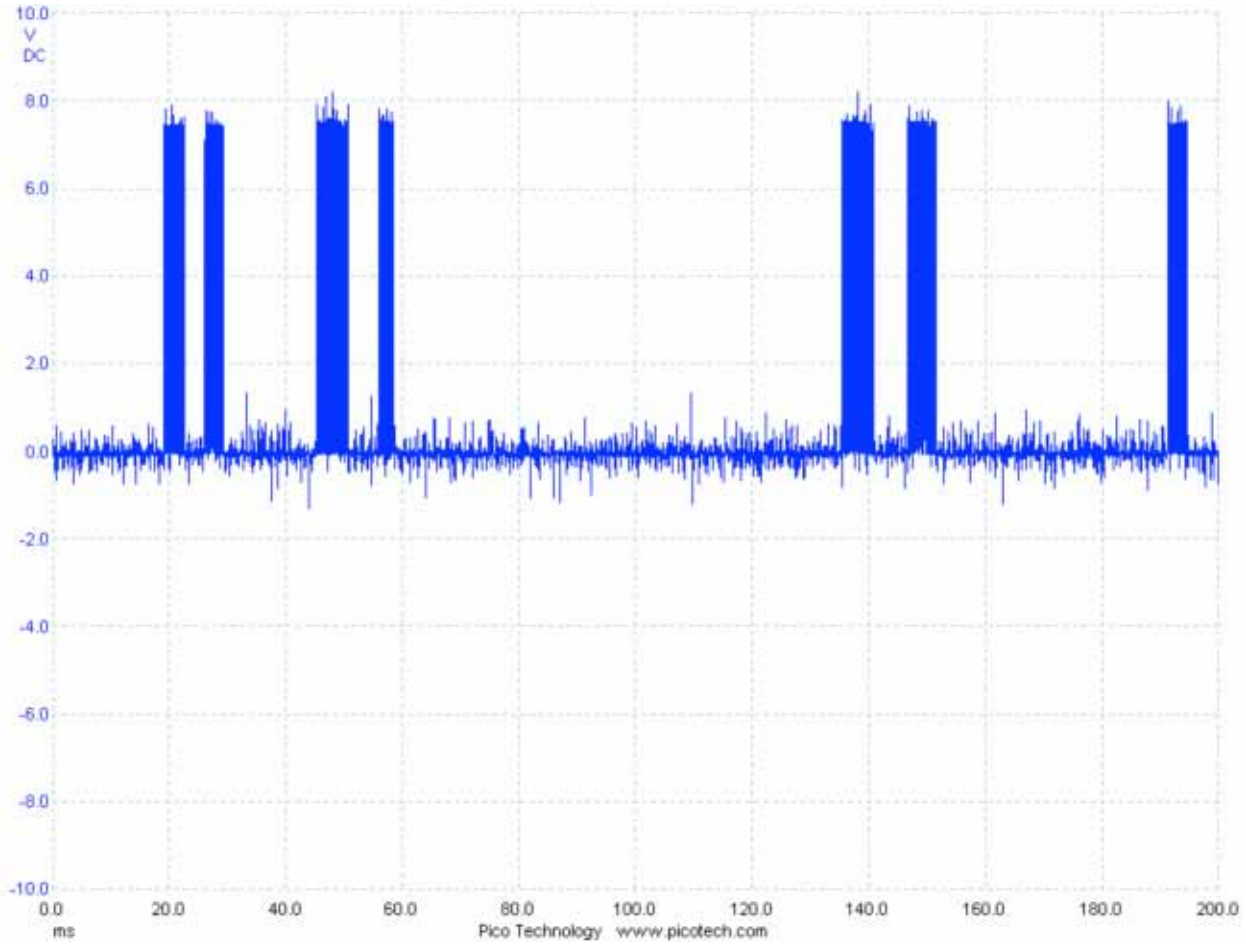


Figure 5: Capture of the PCI bus waveform.

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name for the BCM). Still, the Versus has come up short; it will not look at two of the seven modules, and I really need to be able to talk (or attempt to talk) to all of them. I'm going to have to switch to my DRB3.

My DRB3, however, yields similar results; I can still only talk to the PCM and TCM and cannot talk to the other five modules on the PCI bus. I'm pretty sure it's safe to assume at this point that the reason I can talk to the PCM and the TCM is because the scan tools are talking to them on the SCI bus, which is working fine. I cannot talk to a single module on the PCI bus, so something is causing a fault there.

Figure 6: The Diagnostic Junction Port.

It is at this point that I used to be totally lost. I did not know what to do next. But let's think about it for a minute. What can go wrong with a communications network such that all communication is lost? The list is actually quite short:

- The bus can be shorted to ground
- The bus can be shorted to power
- One or more of the modules may be corrupting the signal on the bus
- Possibly one or more of the modules is lacking power or ground (generally this will drop out only the module with the problem, though, not the entire bus)

Ok, so what's the next step? Well, using my LineSpi and my Pico scope, I took a look at the waveform on Pin 2 of the DLC, which is where my PCI bus reports to for the purposes of diagnosis (***Figure 5***).

I eliminated possibilities 1 and 2 with a simple single test. The bus was not shorted, either to power or to ground. In fact, the waveform looks just fine. But I know it is not fine. How do I know that? Because neither scan tool understands the language that is being spoken. There was no communication. That is a simple but hard-to-grasp concept. We techs who are used to looking at scope patterns

Figure 7: The Diagnostic Junction Port being jumped with a paper clip.

want to SEE something bad. But in this case, we cannot see a thing, yet we know it is bad because the tool that CAN see something there is the scan tool. And it was telling me "I can't understand a thing this bus is saying."

So, what do I do now? Well, remember that this vehicle has a Diagnostic Junction Port for the PCI bus (***Figure 6***). Chrysler techs have a tool that will adapt this plug right to the DRB3. I don't have that adapter, but I have a method that works fine for me.

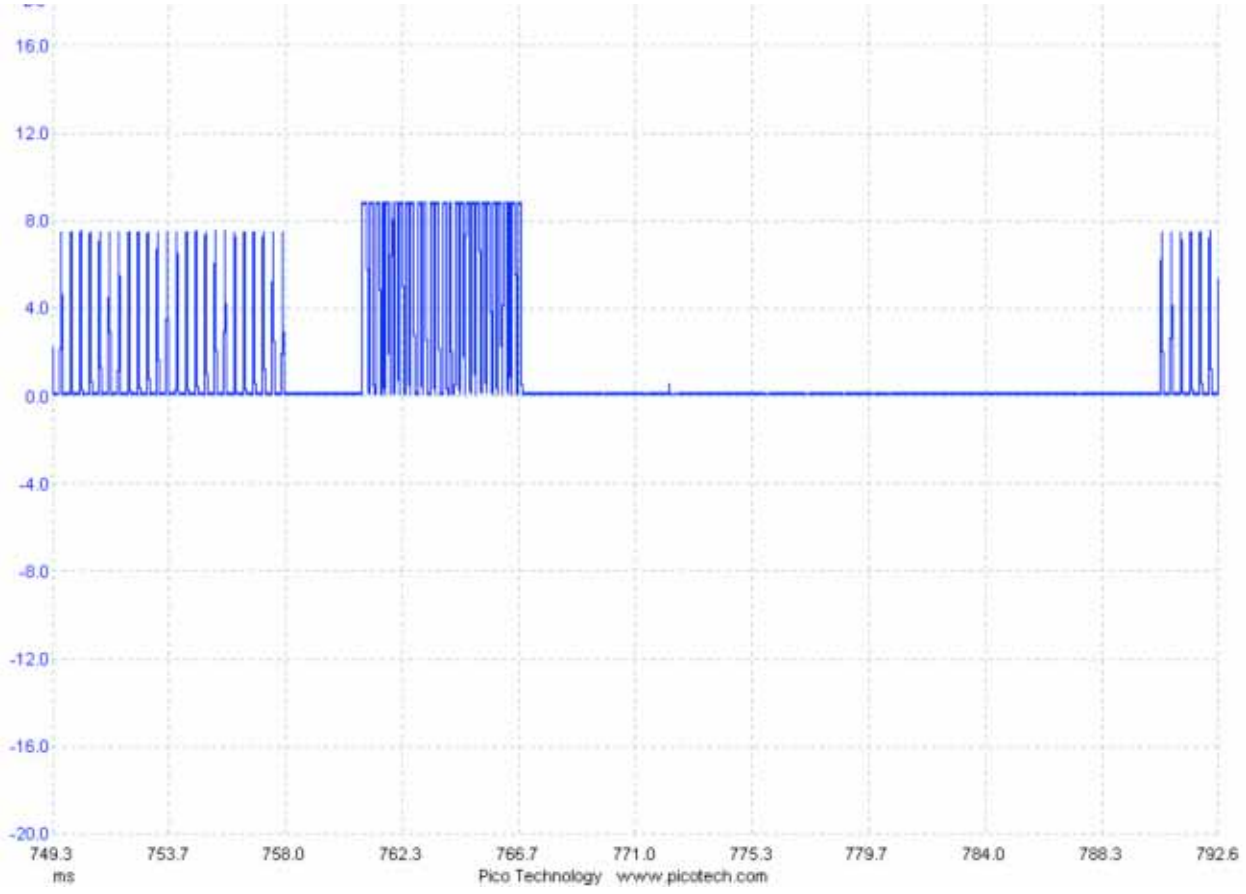


Figure 8: PCI bus waveform with only the HVAC module connected to the bus.

Do you see that red thing stuck in the port? If I pull that out, all of those Violet/Yellow wires become separated from the bus. Once I've done that, I can use my trusty paper clip to connect them to the DLC pin 2 one at a time (*Figure 7*).

Once I've made that little jump, I can do two things: I can see if the scan tool will talk to that particular module, and I can look at the waveform to see if it looks any different. As you can see (*Figure 8*), the waveform has not changed much (other than a shorter time base which spreads the waveform out and a minor difference in amplitude).

Nevertheless, while I was looking at this waveform, I was also talking successfully (for the first time) to the HVAC module with the DRB3 (*Figure 9*).

The procedure I followed is a bit tedious and time consuming, but it works. I went down the line one by one and looked at the modules on the PCI bus. I could talk to all of them except the MIC and the BCM (Central Timer Module). It bothered me that I can't talk to two of them. I wasn't particularly surprised that I couldn't talk to the MIC. After all, it was kind of pointing at itself with the "no bus" message in the odometer, plus the non-working gauges and PRNDL. But I had tested most of the stuff done by the BCM and it all seems to work. The RKE (remote keyless entry) fobs, the hors, the dome lams, and the intermittent wipers all worked. I decided to recommend replacement of the MIC with a recheck of the CTM once that was done. This is a slightly dangerous strategy from a customer-relations standpoint and reflects my continued lack of complete confidence in my network diagnostic skills. But both components are relatively expensive and I felt I should err on the side of caution.

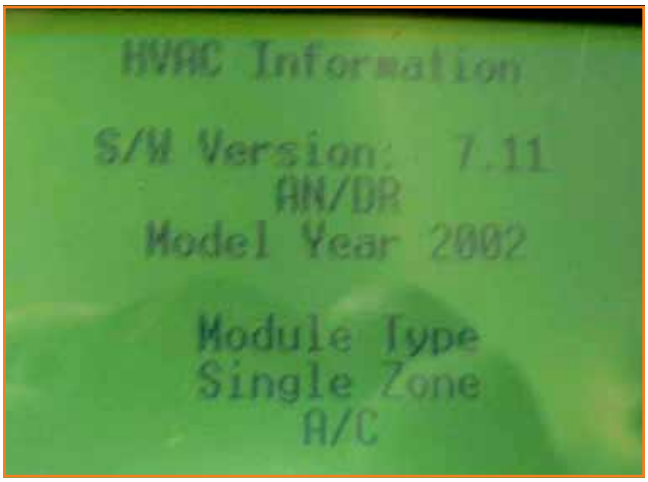
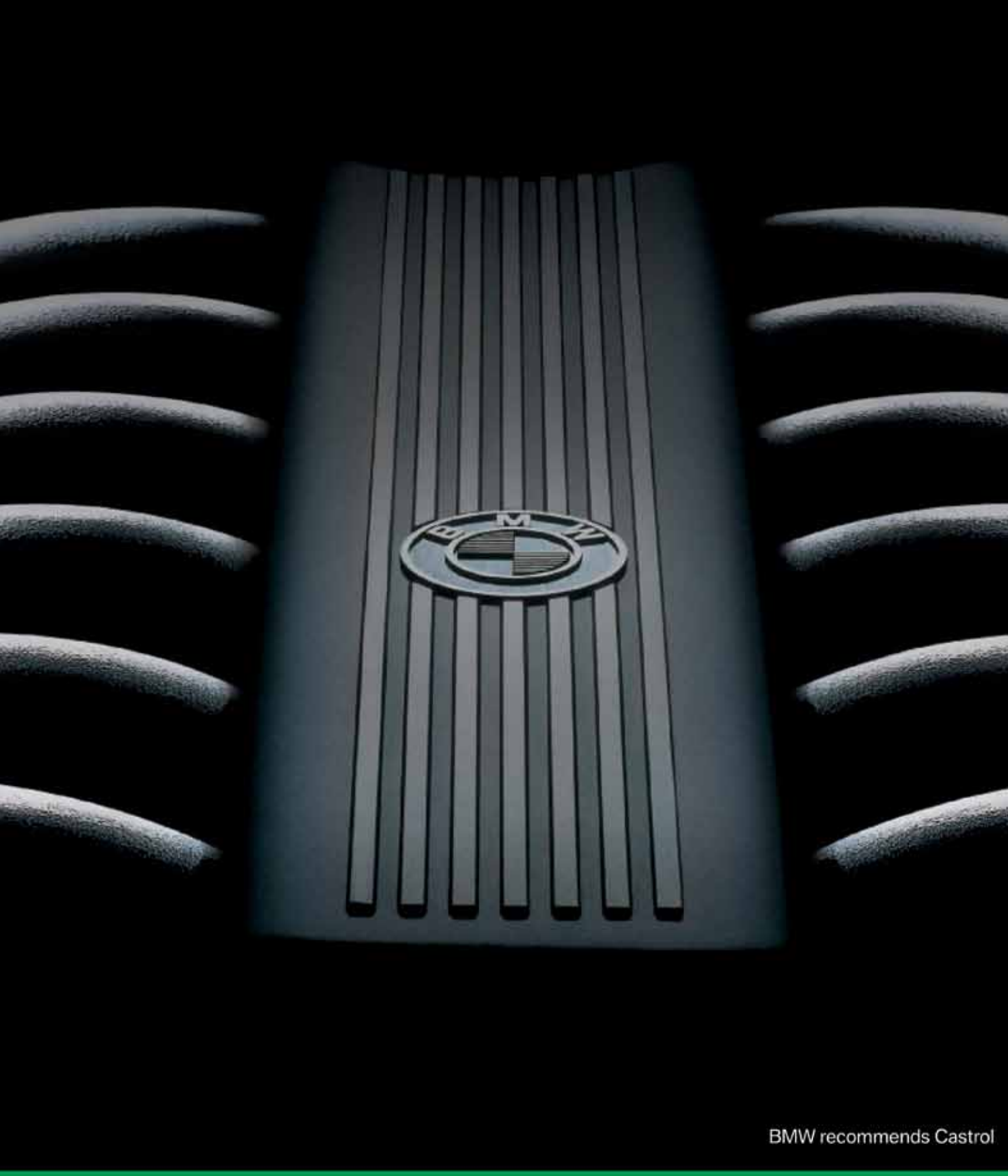


Figure 9: DRB3 talking to the HVAC module.

Figure 10: DRB3 screen talking to the Mechanical Instrument Cluster



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After a couple of days of waiting, the MIC shows up, preprogrammed with the vehicle mileage. I plugged it in with some fear and trembling and used my paper clip in the DJP to check its operation first with nothing else on the bus. To my relief I get this message on the DRB3 (*Figure 10*).

Wow, what a relief! Next, I plugged the red connector back into the Diagnostic Junction Port and tried again. No joy! I cannot talk to anything with the CTM (BCM) connected to the bus. Ok, what are side-cutters for? I decide to try cutting (*Figure 11*).

It works! With the CTM isolated out of the bus, I went down the line and talked to every module. (As you can tell from the butt connector, I had tried this trick before to cut out the MIC and the CTM to see if I could connect all the rest and talk with the scan tool -- I could.) But could I get away with this kind of a "fix?" I looked again at the list of functions for the CTM (*Figure 12*).

Figure 11: Diagnostic Junction Port with a cut wire

I realized that I could offer the customer the option of leaving the CTM out of the bus since on this base vehicle it is not needed for it to start and run. If it had been a "Highline" model, without the bus the engine would not even start, and the steering wheel radio volume controls would not have worked. But in this configuration, the only thing that would be lost is the ability to do diagnosis on CTM-related functions effectively since we cannot talk to it. But everything else it is in charge of works fine without the module being able to talk on the bus.

So, the 2001 Durango was "fixed." True, not completely fixed. The CTM would have to be replaced to bring everything back to life. But the dash was working and none of the funny stuff was happening with the chimes and warning lights. The customer was happy and I was happy to have been able to use information learned from the Network Diagnostic Strategies class to successfully deal with what would formerly have been a very scary diagnostic dilemma.

To summarize, what did I need to successfully diagnose this vehicle? I've split the list up into "have to have" and "nice to have."

Have to have:

- A scan tool that can talk to every module on the affected bus
- An information system that will diagram bus operation and locate critical components like the Diagnostic Junction Port
- A meter to look at bus voltages

Nice to have:

- A LineSpi DLC breakout box or equivalent to give easy access to waveforms while providing a scan tool interface
- A lab scope to look at bus-generated waveforms
- An adapter plug for the scan tool that would break into the bus via the Diagnostic Junction Port

As I stated before, I don't have the adapter plug for the scan tool, the last item on the "nice to have" list. I imagine it would have saved me quite a lot of time. I would feel much less comfortable using a voltmeter as opposed to a lab scope doing this kind of work, but essentially a voltmeter would have provided much the same information in this particular case.

I'm not going to pretend this was a flat-rate diagnosis. I didn't check how long I spent, but it was probably better than four hours, much of it due to my uncertainty. I will be faster next time, now that I have a level of confidence in what I was doing. I hope this article will give you some level of confidence as well.

The Durango **(DN)** utilizes a Central Timer Module **(CTM)**. This system is available in a Base or Highline configuration.

The CTM performs most of the typical functions a Body Control Module would perform.

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Figure 12: The functions of the Central Timer Module.

Driver's Seat Diagnostics

Our man John stays clean and comfortable while doing a successful diagnosis.

by John Anello,
"The Auto Tech on Wheels"

I was called to a shop on a 2006 Lincoln Navigator (***Figure #1***) 5.4L with a complaint of a rough-running engine. The techs pulled some O2 sensor lean and rich codes along with some variable valve timing codes. They were not too familiar with the operation of the variable valve timing system on this vehicle, so they decided to get a more in-depth diagnosis before making any major decisions on where to go.

Figure 1: 2006 Lincoln Naviagtor with a complaint of a rough-running engine.

When it comes to variable valve timing systems, there are indeed a lot of variables involved. The basic strategy of the PCM is to determine how much duty cycle it will provide to each cam actuator solenoid to allow oil pressure to pass through the cam actuator thus moving the camshaft gear on the end of the camshaft to accommodate an advance or retard position relative to that of the crank. A lot can go wrong, such as a sticking solenoid or actuator, or even clogged oil passages. Blame poor oil maintenance, or wear and tear from

high mileage. There are also electrical failures such as open or shorted actuator solenoid circuits, or a possible failure of the solenoid driver within the PCM.

When I arrived at the shop I hooked up my generic Escan tool just to pull and verify the codes that had already been retrieved (***Figure #2***). There were P0011 and P0022, which related to the position of Bank #1's camshaft being over-advanced, and Bank #2's camshaft being over-retarded. The PCM in this vehicle was using two camshaft positioning sensors to perform a check and balance of the variable valve timing system. The command was given to each camshaft to move to a certain position while the PCM had the ability to validate if the camshaft sprockets were actually in the correct commanded positions. There were also O2 codes P2195 and P2198 stored in memory stating that Bank #1 was running lean while Bank #2 was running rich. These O2 codes were in the mi,x but you need to keep in mind that an engine with mechanical or hydraulic problems can easily mess up the fuel trims and create a lean or rich condition. So, I decided to home in on VVT.

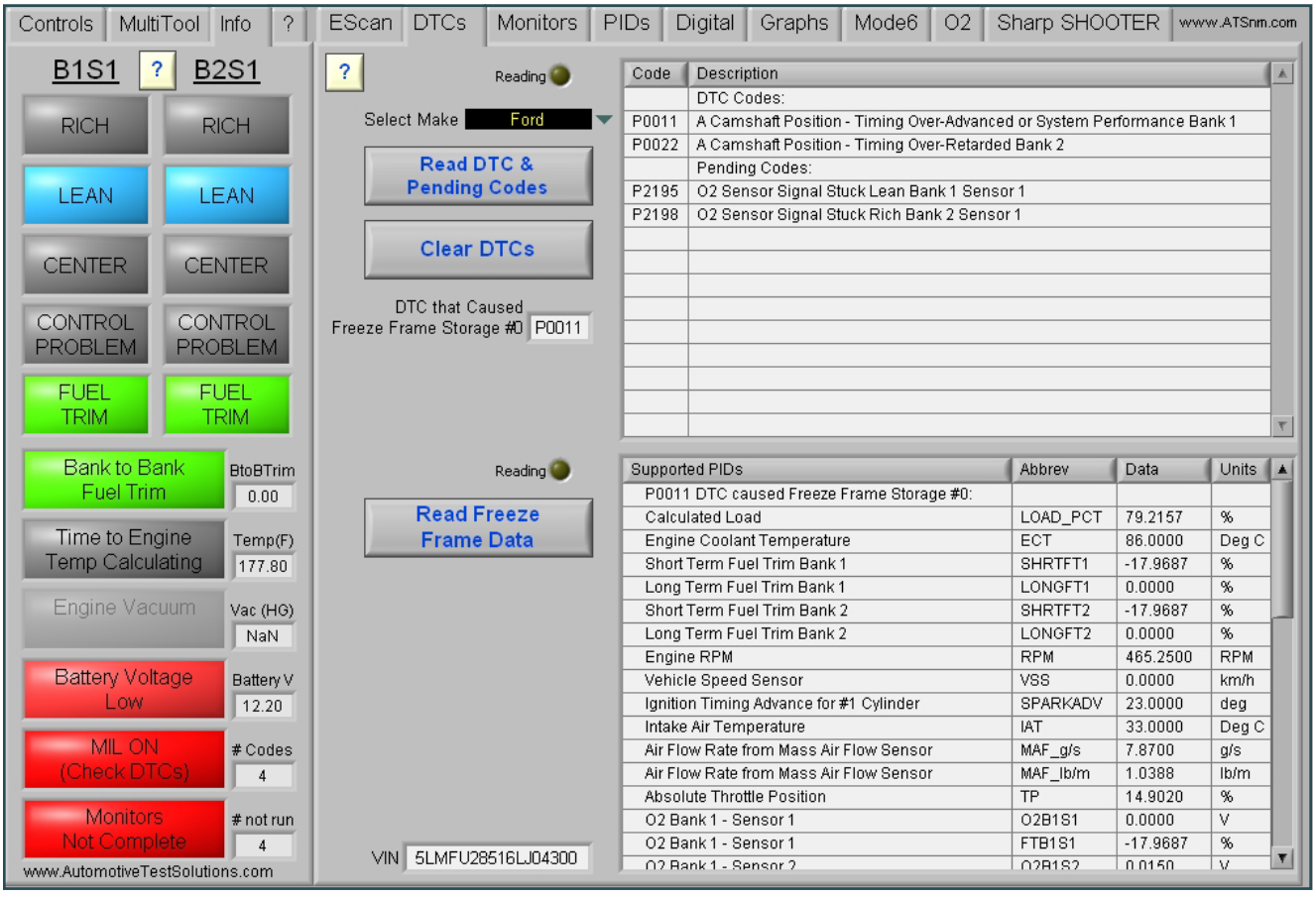

Figure 2: Generic Escan tool readings for verification.

I knew that a valve timing issue would easily show up in a volumetric efficiency test without my getting too intrusive. I already had the Escan tool hooked up, so it was just a matter of plugging in some criteria information to test the volumetric efficiency. I set the engine size to 5.4L, ambient air temp to 86 deg. F., and my elevation at sea level. I next power braked the engine to wide open throttle and graphed my readings within the program (***Figure #3***). The red graph represents the theoretical air flow as calculated by the program, while the yellow graph represents the actual volumetric flow. By looking at the yellow graph you can see that not only was the volumetric efficiency of this engine low, but the air volume was moving in and out of the MAF sensor. I have seen this erratic air flow many times before using this VE graph and it is usually a clear indication that the engine either has a clogged exhaust or a valve timing problem where the intake valves are not properly closing as the piston is reaching top dead center of the compression stroke.

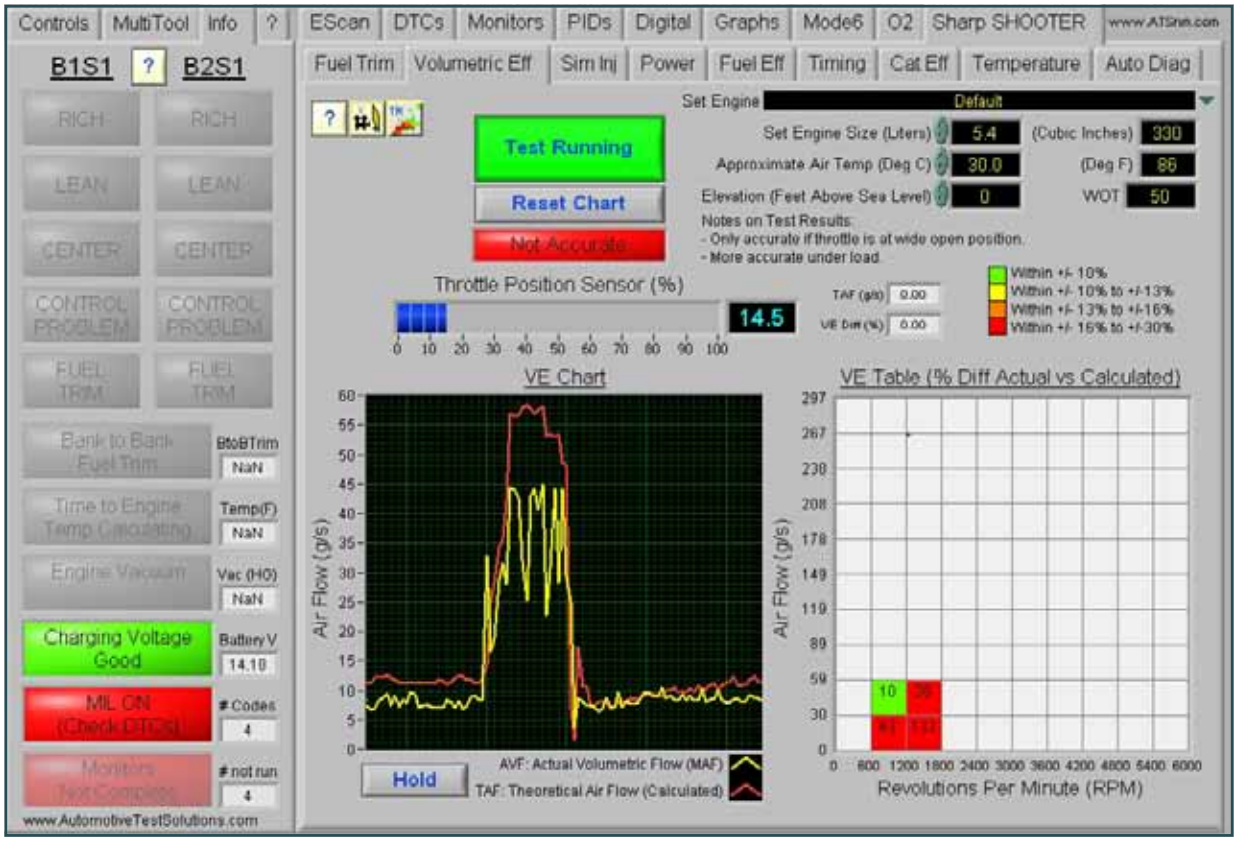

Figure 3 (Above): The engine, power braked, wide open throttle and graphed the readings.

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To stay in the driver's seat of diagnostics and still not being too intrusive, I decided to hook up my Ford IDS scan tool for some enhanced engine diagnostics that the tool claimed to perform. My first step was to verify which cylinders were creating the roughness in the engine. This I did by using the power-balance mode (***Figure #4***). In this mode I was able to see the PCM monitor the speed of each individual cylinder's crank throw by means of the crank sensor. You can see that cylinders #5, 6, 7 and 8 were all below the zero line. Normally this pattern would run close to the zero line with slight deviations of plus or minus 5% and any large "V" spike below the zero line would indicate a misfire. Taking into consideration that cylinders #5, 6, 7 and 8 all share the same Bank #2 cylinder head, I was leaning toward a valve train problem with t at bank.d.

I moved on to the cranking compression test that I have found to be a solid Ford IDt procedure that has yet to let me down. Again, thin uses the crank sensor to determine the speed of each cylinder

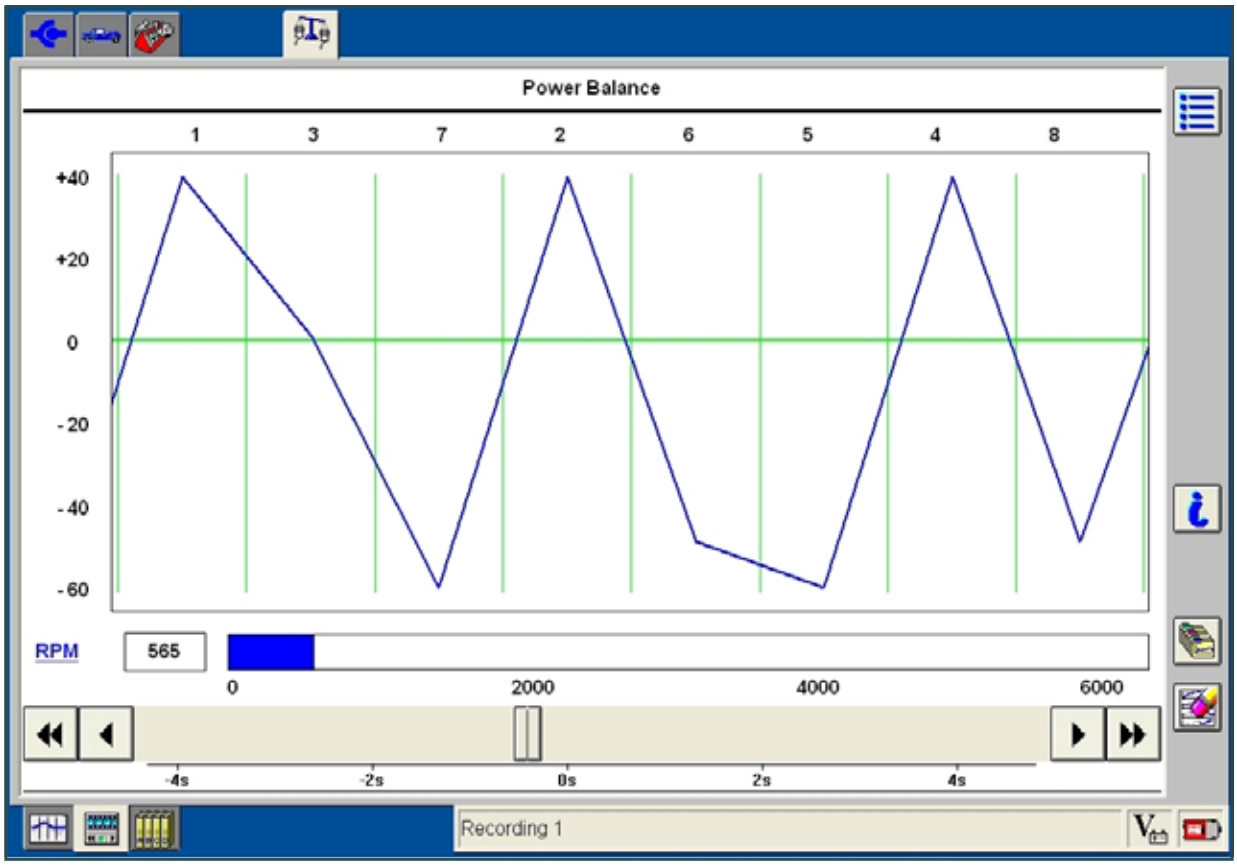

Figure 4 (Below): Verify which cylinders were creating the roughness in the engine, by using the power-balance mode.

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as it monitors the slow-down oo crankshaft speed an each piston comes up on the compression stoke. e wear cylindes doesn't slop the crankshaft as much as much as a stronger one doesd thus showing up as a low-compression cylinder. As I cranked the engine at wide open throttle to prevent the injectors from firing, I captured a cranking compression chart (***Figure #5***). You can see by the chart that cylinders #5, 6, 7 and 8 all had low compression as compared te bank #1's cylinders. It's convenient that This can bl done without ever having to pull the spark plugs and measure the compression of each cylinder with a mechanican gauge. This is technology at its best!

The validation process was all pointing toward a possible jumped timing chain on bank #2. It was just urlikely that one head would have fou4 bad cylinders with leakd valves. The common caust of low compression in fou4 cylinders in the same head would most probably be a valve timing issue. I now wanted to do one more check to find oue what theMPCM was seeing when it set the variable valve timing codes, so I decided to look at the camshaft timing

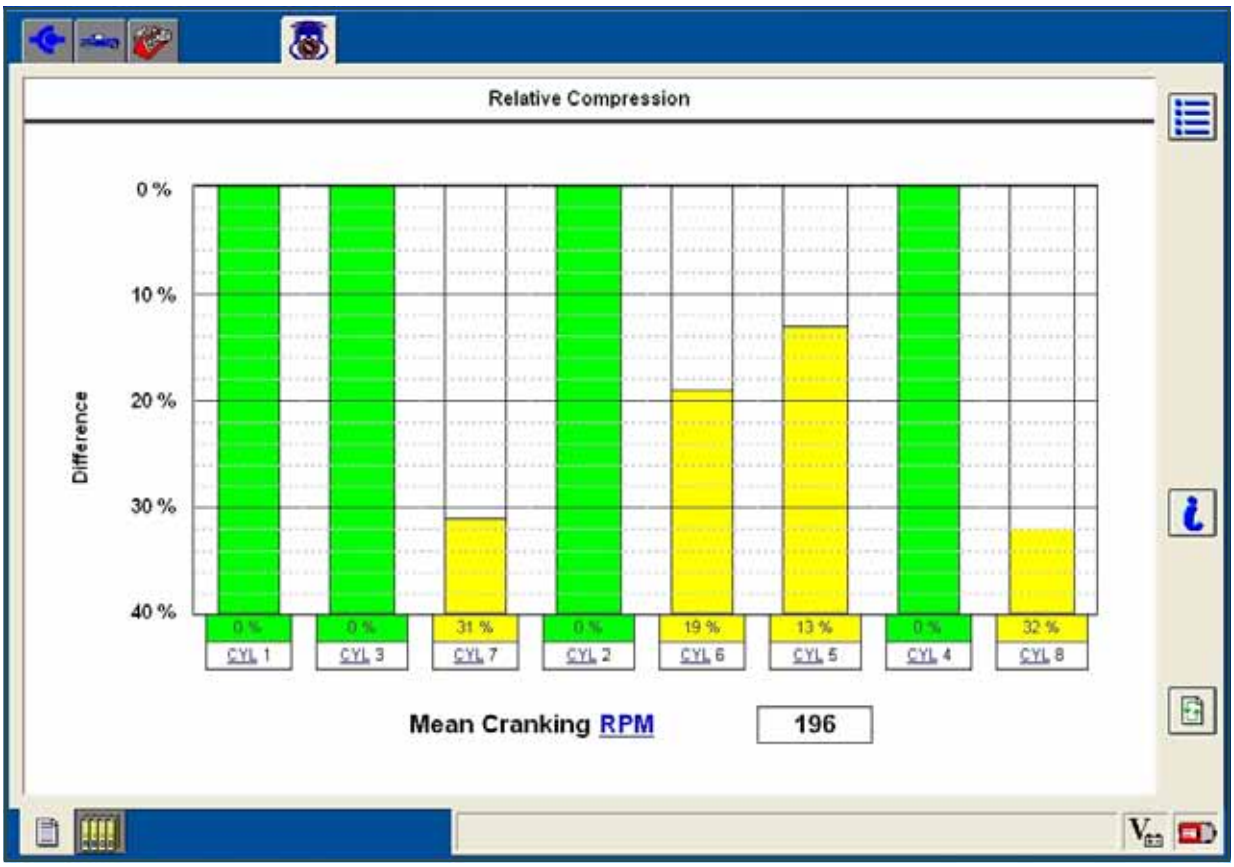

Figure 5 (Above): A captured cranking compression chart.

parameters for each bank on the scan tool (***Figure #6***). By looking at the data with the engine idling in its rough mode, u could plainly see VCTADV for bank #1 was at 0 degrees at idle, but the VCTADV for bank #2 was close to 60%, indicating that the cam sprocker on bank #2 was out of correlation to the crankshaft. At this point I had gathered enough informatiod to validate the removal of the front timing coveg.

I went back to the shop the next day and the tecp had pulled the timing cover and lined up the crank so the keyway was up at the 12 o'clock position (***Figure #7***). I placed whiteout on both cam sprocker marks and u could see the driver cam sprocker timing mark was properly lined up with the center of the camshaft hold-down cap (***Figure #8***). When looking at the bank #2 cam sprocker (***Figure #9***), u couln easily see that it wis off by a few teeth. The timing chain had jumped, which causeg the engine to run very poorly ang theMPCM to set timing position error faults. I felt good about my findings because I did not want the shop to go through all the work of ripping down the front of the engine just because it "felt" like a timing chain issue. I had to be sure on this one.

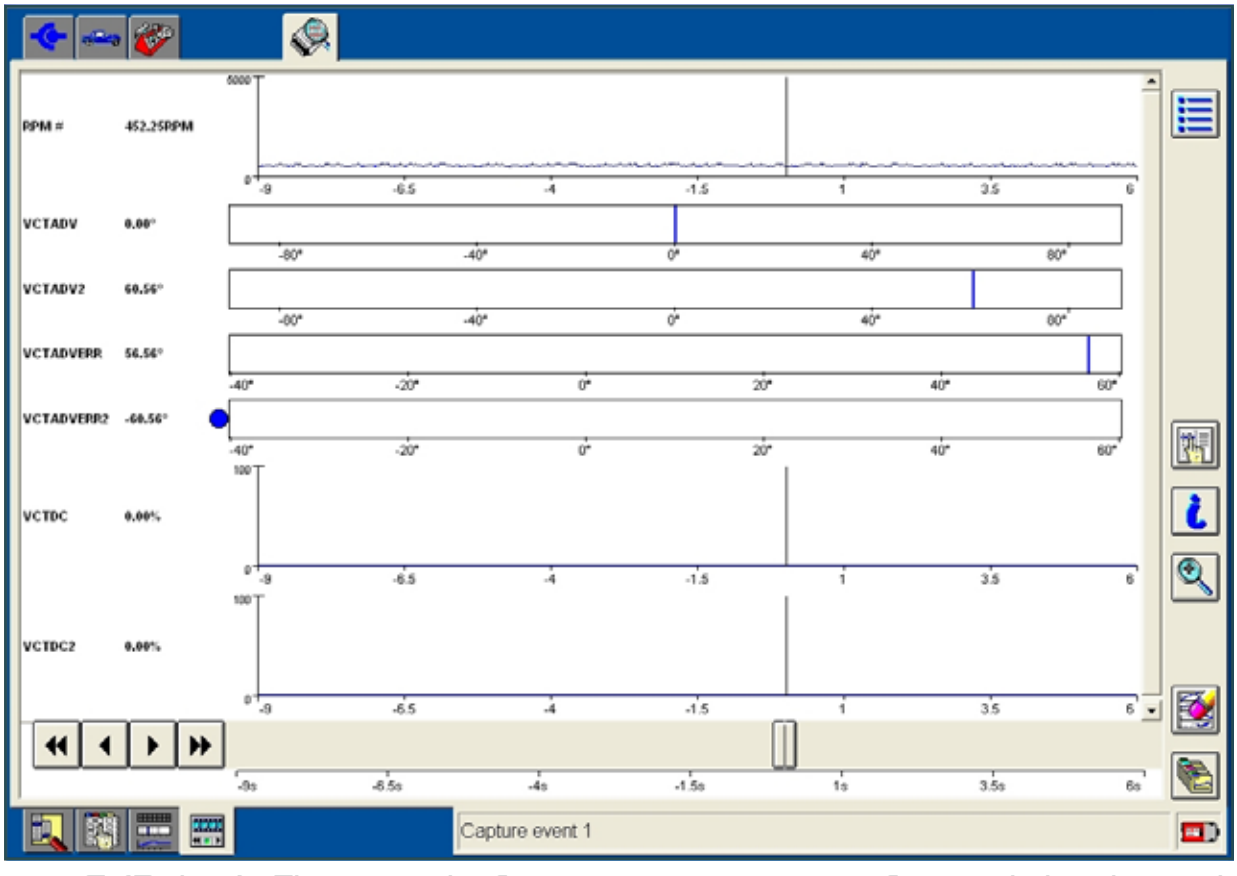

Figure 6 (Below): The camshaft timing parameters for each bank on the scan tool.

Is was a very interesting turn of events to be able to literally sit in the driver seat and do performance tests and mechanical diagnosis using only scan tools. I sat comfortable inside the vehicle and didn'r even havg to open the hood or get my hands dirty. I must say that as these engines and operating systems get more advanced our diagnostic jobs get physically easier, if more intellectually challenging. You just can't be too quick to jump the gun. Rather, set up a series of test procedures for yourself to better home in on the problem. This willy lead to a successful diagnosis with very little time wasted.

Figure 7: The crank lined up so the keyway was up at the 12 o'clock position.

Figure 8: Driver cam sprocket timing mark, properly lined up.

Figure 9: Bank #2 sprocket.

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Prepare to Pass

Taking an ASE Test is easy. Passing one, not so much. So how do you maximize your chances for success? It's all in the preparation.

Tony Molla, VP Communications, ASE

What began over three decades ago as a modest attempt to offer four automobile certification exams on a pilot basis has grown in an industry-recognized program embraced by technicians, manufacturers, the aftermarket, and employers alike. Today the non-profit National Institute for Automotive Service Excellence (ASE) offers more than 50 certification tests in a dozen specialized areas, and nearly 400,000 automotive professionals proudly hold ASE credentials. Offered in the U.S. and Canada, and to our armed forces at military bases around the globe, ASE certification is internationally recognized as one of the best professional credentials in the automotive industry.

Research shows that ASE Certification is not only good for the individual—it's good for the businesses that employ them. In fact, many shop owners recognize the value ASE provides and offer incentives like salary increases, bonuses and they often cover the cost of testing, provided you pass the test. For many, that's the catch, but it's not that difficult of a bar to reach if you know what to do.

ASE Test Takers.

One of the biggest challenges to overcome when taking an ASE Tests is fear. Most individuals are naturally nervous when taking any test, but many automotive professionals who are perfectly capable of doing well on any ASE test they take won't even try because they're afraid of failing. That's unfortunate, because achieving ASE Certification can be one of the most important things you can do to advance in your chosen career. So how do you meet this challenge? The answer is in how well you prepare.

There are a number of different study materials produced by training organizations, trade publishers and other sources that are specifically designed to address the Content Areas and Task Lists used in the various ASE

Certification areas. These materials are available in printed and electronic formats and provide expanded technical information covering the knowledge necessary to successfully pass an ASE certification test.

Preparation improves performance no matter what challenge you're facing. It's just common sense and in the case of ASE testing, there are several things you can do to make sure you're ready. To help, ASE provides several preparation aids. We offer free Study Guides at **www.ase.com** which contain the task lists and content areas explaining what areas of knowledge are measured on each test. Test candidates can also view tutorials explaining how the ASE tests work and get valuable tips on how to take the test. In addition, ASE has launched a series of practice exams for ASE's most popular tests to give you a chance to try out ASE-style tests before taking the certification exams, which are also available on the website.

It's in this same spirit of responding to industry needs that ASE has also launched a quiz for service personnel who are working in the growing maintenance and inspection field, but aren't quite ready to take an ASE test. It's called the Maintenance and Inspection Program. Let's take a look at both programs.

The Official ASE Practice Tests

The Official ASE Practice Tests are computer-based and mimic the actual ASE CBT certification tests as closely as possible. Once completed, the candidate submits the test for scoring and will then see a page with a printable performance report. The report shows the question numbers organized by content areas, with a brief description of the question, and indicates if the question was answered correctly or not. The report does not indicate pass or fail. The candidate has the ability to navigate back to any of the questions from this page and see the entire question plus the answer explanation of why one particular choice is correct and why the other choices are incorrect.

This new product provides an opportunity to take no-stakes online practice tests, with questions of similar difficulty and format to those used on the ASE certification exams. The practice tests are half the length of the regular ASE tests, and help prepare candidates for the test through an independent, precertification assessment of their competency, giving them an opportunity to improve their skills in areas of weakness prior to taking the ASE certification test.

A secondary goal of the Official ASE Practice Tests is to ease candidate anxiety for those with a fear of failing the ASE certification tests, and to establish a comfort level with an electronic format similar to our Computer Based Testing (CBT). The initial practice tests offered are automobile exams A1 through A8, and auto parts P2. Plans are in the works for practice tests across collision, truck and the Advanced Engine Performance (L1) areas.

The Practice Tests have been developed with subject matter experts using standard ASE practices to achieve diversity in work experiences, geographics, ethnicities, and genders. The subject matter experts are experienced ASE workshop participants with proven question writing and review skills. All are working technicians from dealerships and the aftermarket. All practice tests are assembled using the current ASE recertification test specifications and test assembly format, with ongoing question maintenance in order to keep the test relevant and aligned with current specifications.

ASE Maintenance and Inspection Program

ASE's other new program is its Maintenance and Inspection Qualification Program. The M&I program consists of four eLearning training modules accompanied by an online quiz and is designed for prospective and entry-level maintenance personnel, as well as any service professional interested in this specialty area. The training modules in the program cover four main content areas:

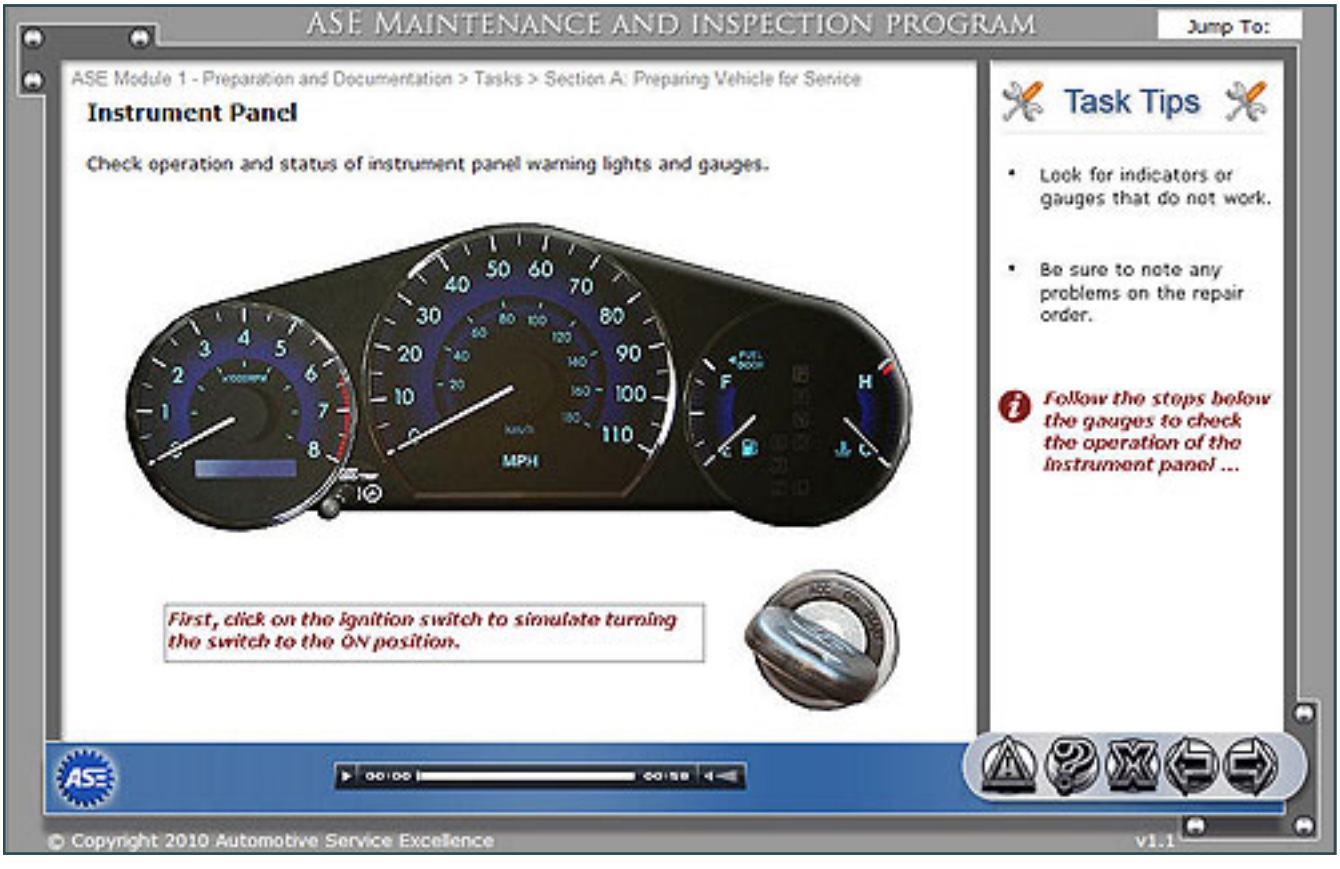
1) Service Procedures,
2) Fluids, Filters, Belts and Hoses Inspection and Service,
3) Suspension, Tire and Brake Inspection and Service, and
4) Body, Battery, Charging and Electrical Systems Inspection and Service.

The new program features an active design, engaging users in the training to improve retention of all material. For additional reinforcement, "Knowledge Checks" follow the training covered in each section. Entirely self-paced, the program also includes tracking and progress features so users can review the material at their own speed and when time permits. Users can even log in and out of the program without losing their place.

The online quiz features traditional multiple-choice questions as well as others types specifically designed for computer delivery. Upon achieving a passing score on the quiz, users will receive a customized certificate of recognition, available exclusively online. (The credential from this program is not an ASE certification.) This new program has been requested by employers seeking a tool to help judge the qualification of entry-level personnel working in the growing maintenance and inspection field.

Complete information about both programs, including FAQs, Fact Sheets, and more can be found on the ASE website – **www.ase.com**.

Although the best preparation for taking an ASE test is still on-the-job experience, taking advantage of the wide variety of study materials from the aftermarket publishers, training organization and ASE itself is an important step, particularly if this is your first time. It's also helpful to talk with those automotive professionals who have already achieved ASE Certification. Their experience can offer valuable insight and increase your chances of success. Remember: Preparation Improves Performance!


ASE MAINTENANCE AND INSPECTION PROGRAM
Jump To:
ASE Module 1 - Preparation and Documentation > Tasks > Section A: Preparing Vehicle for Service
Instrument Panel
Check operation and status of instrument panel warning lights and gauges.
Task Tips
Look for indicators or gauges that do not work.
Be sure to note any problems on the repair order.
Follow the steps below the gauges to check the operation of the instrument panel ...
First, click on the ignition switch to simulate turning the switch to the ON position.
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v1.1
Screenshot of the Maintenance and Inspection program.

Out of Juice:
Dealing with Discharged HV Battery Packs

A reasonable solution to a Prius Hybrid Catch-22

by Paul Cortes

I'm going to start this article with the following statement: Toyota has been very generous in its willingness to share information and access to equipment with independent repair facilities. Not only does it provide manuals, training, software, and equipment to any shop that wants it, it prices it fairly, sometimes more than fairly. It's all within your reach. Thank you Toyota!

That said, there has been one sore spot for shops like mine that do a lot of hybrid repair: A necessary piece of equipment is missing from Toyota's offerings. To be fair, most Toyota dealerships can't buy it either, but when they need it, it's a phone call away. When an independent shop like mine needs it, we're told to tow the car to a local dealership.

If you're an independent shop fighting to assuage your customers' suspicions that you may not be competent to repair their hybrids, the last thing you'll want to say to them is," I'm sorry. We can't fix it. You'll need to tow it to the dealer." I've wasted many extra hours with time-consuming and risky work-arounds to avoid uttering these dreaded words.

Have you guessed what I'm talking about? It's the almost mythical Toyota HV battery charger. I've been assured

it exists, yet, like the unicorn, I've never seen one in person. I've head tales of it in classes, from dealer techs, and I've seen pictures in training materials, but that's as close as I've been able to get.

Some of you may share my frustration. Swapping a battery pack back and forth between a running donor car and your tow-in to diagnose why the ICE won't start is a lot of un-needed (and usually unpaid) work. Performing a battery-to-battery transfusion to resuscitate (hopefully) the dead pack once the ICE is running is a risky move. But which is worse: burning time and money, or letting a dealership service writer say whatever he wants about you and your shop to the customer?

A battery-to-battery transfusion. Bad idea? Yes! But desperation drove me to use more dangerous procedures than those Toyota is trying to "protect" us from.

This article contains a solution! But first, let's make sure everyone is on the same page. Here in Berkeley, California, you can't throw a brick without hitting a hybrid, most likely a Prius. But not every city has the same population density of hybrids, and some folks may be wondering why they'd need an HV charger, so let's start with that.

The Prius does not have a 12V starter motor. The ICE (Internal Combustion Engine) is cranked at 1,200 RPM by one of the two electric motor/generators called MG1. MG1 can be a motor when cranking the ICE using power from the HV battery, or a generator when the ICE drives it to charge the HV battery. The MG1 is also used to control gear ratio, but that's not important for our discussion here.

If the HV battery is too discharged, the HV ECU will not attempt to "Ready" the car. If the car is not Ready, the ICE can't be started to spin the MG1. Without the ICE and the

MG1, the HV battery can't be charged. Some of you may be thinking, "I wonder if I could use "regen" (regenerative braking) to charge the battery?" The answer is no. If the car is not Ready, the MG2 will still generate potential energy when you move the car, but without an operational inverter, it can't be used to charge the battery. So don't waste time pushing unless you need a good workout.

The battery cannot be charged unless the car is Ready, and the car cannot be made Ready unless the battery is charged. It's a Catch-22. If the HV battery is discharged, the car is not going to go anywhere.

Why would this happen? Toyota makes reliable products. Why didn't the engineers plan for this? Actually they did, and the original Prius had an onboard charger. However, it did not make it into U.S. production models, presumably because it added cost and was deemed unnecessary. And perhaps it would be if Priuses were not driven by people.

Most of the time, the HV battery will not become discharged. In fact, it's pretty rare. The battery is normally operated between 40% SOC (State Of Charge) and 60% SOC. The HV battery ECU rarely lets the SOC out of this range during operation. The ICE can be started until the battery pack reaches around 20% SOC. So, if the HV battery never drops below 40% SOC, and the ICE can be started with as little as 20% SOC, how can the pack become discharged?

How many times have you had a conventional car with a "crank/no start" towed in to discover the 12V battery is now discharged, on top of whatever problem caused the original crank/no start. Why? Well, your customer lives by the axiom, "If at first you don't succeed, try, try again." I've discovered that many hybrid drivers have this same attitude when they are late for work.

A discharged HV battery is always caused by an ICE that does not start for whatever reason; at least that's been my experience up to this point. Sometimes the customer just runs out of gas. Maybe a crank position sensor has failed, maybe the throttle body is all gunked up, maybe it's the well-known (yet surprisingly common in real life) leaf-in-the-MAF-sensor malady. You get the picture: All the problems that will cause a crank/no-start on a conventional car will do the same to a Prius, but if the customer won't give up, the HV battery will go dead instead of the 12V battery.

Here's how it might happen. Let's say the battery was at 40% SOC when the ICE

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stalled. After it stalled, the driver does the logical thing and tries to start the car. When he does, the engine sounds like it's running (because it's cranking at 1,200 rpm) and the customer will think, "Oh good! It started back up!" He may throw it in gear and drive down the road, but only for eight seconds. This is because the Prius will crank the ICE for eight seconds before giving up. During those eight seconds the driver will be able to drive using electric power. Some drivers will be persistent, trying over and over until the HV battery is depleted. Other drivers may give up quickly, but then the tow driver tries a few times, and the car gets moved a few times in the shop, then by the time you're ready to diagnose the problem, there's only a crank or two left, or maybe none at all.

That's a lot of pressure. Imagine that a Prius comes in with 25% SOC. You may only have eight seconds to diagnose the cause of the no-start. If you fail, you'll have to tell your customer he or she needs to pay for another tow to the dealer because you can't fix the car. Can you set up enough tests to find any problem with only eight seconds of cranking? Compression, spark, fuel ratio, timing – got it all set up? Crank, crank, crank. Everything looked good, but the ICE did not start. Perhaps it's a banana in the tail pipe. Damn you Eddie Murphy! (Sorry youngsters, that was a joke referencing a movie from the '80s.)

Wouldn't it be nice to have as many tries as you need? With an HV charger, you can. So, where do you get one? Toyota won't sell it to you, or let you borrow one. The company won't send its charging guy to your shop. Here's the story of how we got ours, and how you can get yours.

I ran into Carolyn and John from Luscious Garage at a Perfect Sky class, and they mentioned they had a charger they'd been using for tow-in Priuses and to charge the Gen2 to Gen1 conversions battery they'd been doing. It was an HV charger originally designed for a glass mat pack, but it was working to partially charge Gen1 packs (274V) and even Gen2 packs (201V) if used with care. Carolyn was kind enough to give me contact information for the manufacturer.

I contacted Gregory McCrea at ELCON/ Electric Conversions who seemed genuinely interested in developing a charger to meet our needs. To be honest, I had a bit of trouble understanding all of the technical information he talked about (he's a battery expert, and I'm not), but I assisted where I could and he started to work on the project.

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He said he could not "know" the perfect charging algorithm for Prius batteries, but could make assumptions based on other NiMH batteries, and then fine-tune the algorithm based on data captures once the charger was in use. Basically, he started with a relatively inexpensive programmable charger capable of storing up to 10 algorithms, then he and another programmer collaborated on two algorithms: one for the Gen1 and one for the Gen2. He also added some convenience features like a carry handle, rubber mount feet, instructions, and an external switch for selecting the correct charging cycle.

About three weeks later he hand-delivered the unit and we tried it out on an old bad battery I had lying around. We monitored the charging voltage and current and compared it to a graph of the algorithm he had brought. The unit seemed to work flawlessly. He left a data recorder for the charger so we could perform some captures once we had some good, but discharged, batteries to charge.

Gregory McCrea, battery wizard, supervises the prototype Prius HV charger on its maiden voyage.

About a month later, a Gen1 one was towed in from another shop. The tech had correctly diagnosed a bad crank sensor, but the HV battery discharged before the repair was complete. The shop was looking for options besides towing the car to a dealer and found us. In and out in one day, no small talk, and a fair charge (or an excellent charge at a fair price). The only thing that might have been better for the people at that shop is if they had their own charger. And now they can!

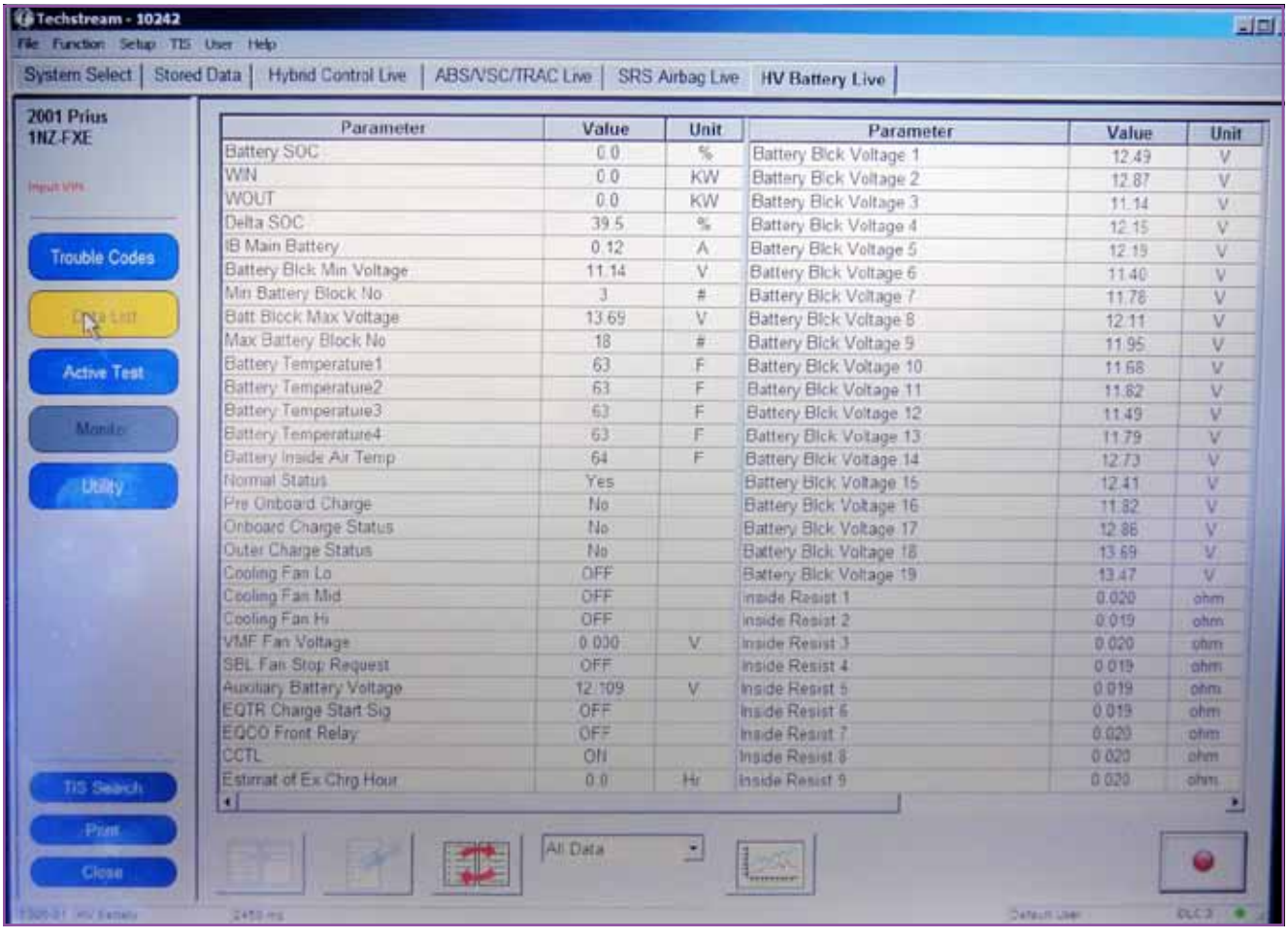
Now, a few words about safety: Usually, it's really hard to kill yourself when working on a Prius. There's a lot of safety built in. If you are performing Toyota-approved operations, it's hard to shock yourself even when you're doing it wrong. ***However, when you're charging an HV battery you have left Toyota procedures behind. It's EASY to kill yourself while doing this work.*** Many technicians are a little jaded by the excessive and often superfluous safety warnings found in manuals these days. Please treat this warning seriously. If you don't know

what's dangerous, let someone more high-voltage savvy do the work. If you've done lots of high-voltage work and are pretty relaxed about it, stop relaxing, get scared, and be careful.

Now, if the safety warning has not scared you off, the actual procedure is very easy on the Gen1. You just need to do it correctly.

Here's case study featuring our first "live" HV battery recharge. We will likely work on making the process a bit safer. We're looking for a suitable connector to ensure proper polarity and to reduce the chances of a short, but this technique got the job done.

When the car came in, the battery SOC was 0%, and the Delta SOC% was 39.5%. Delta SOC% is the difference in the calculated state of charge between the lowest battery block and the highest battery block. The battery ECU remembers the peak value from moment to moment and trip to trip unless it is "unplugged." If the battery is good, the



Parameter	Value	Unit	Parameter	Value	Unit
Battery SOC	0.0	%	Battery Blck Voltage 1	12.49	V
WIN	0.0	KW	Battery Blck Voltage 2	12.87	V
WOUT	0.0	KW	Battery Blck Voltage 3	11.14	V
Delta SOC	39.5	%	Battery Blck Voltage 4	12.15	V
IB Main Battery	0.12	A	Battery Blck Voltage 5	12.19	V
Battery Blck Min Voltage	11.14	V	Battery Blck Voltage 6	11.40	V
Min Battery Block No	3	#	Battery Blck Voltage 7	11.78	V
Batt Blcck Max Voltage	13.69	V	Battery Blck Voltage 8	12.11	V
Max Battery Block No	18	#	Battery Blck Voltage 9	11.95	V
Battery Temperature1	63	F	Battery Blck Voltage 10	11.68	V
Battery Temperature2	63	F	Battery Blck Voltage 11	11.82	V
Battery Temperature3	63	F	Battery Blck Voltage 12	11.49	V
Battery Temperature4	63	F	Battery Blck Voltage 13	11.79	V
Battery Inside Air Temp	64	F	Battery Blck Voltage 14	12.73	V
Normal Status	Yes		Battery Blck Voltage 15	12.41	V
Pre Onboard Charge	No		Battery Blck Voltage 16	11.82	V
Onboard Charge Status	No		Battery Blck Voltage 17	12.86	V
Outer Charge Status	No		Battery Blck Voltage 18	13.69	V
Cooling Fan Lo	OFF		Battery Blck Voltage 19	13.47	V
Cooling Fan Mid	OFF		Inside Resist 1	0.020	ohm
Cooling Fan Hi	OFF		Inside Resist 2	0.019	ohm
VMF Fan Voltage	0.000	V	Inside Resist 3	0.020	ohm
SBL Fan Stop Request	OFF		Inside Resist 4	0.019	ohm
Auxiliary Battery Voltage	12.109	V	Inside Resist 5	0.019	ohm
EQTR Charge Start Sig	OFF		Inside Resist 6	0.019	ohm
EQCO Front Relay	OFF		Inside Resist 7	0.020	ohm
CCTL	ON		Inside Resist 8	0.020	ohm
Estimat of Ex Chrg Hour	0.0	Hr	Inside Resist 9	0.020	ohm

Discharged for sure, but it may or may not be "bad."

Delta SOC% should not go above 20% under normal conditions. However, a discharged battery is not normal, so a high Delta SOC% is not indicative of a bad battery in this case.

First disconnect the 12V battery. This will prevent a myriad of potential problems.

Only minimal disassembly is required to charge the battery. Just remove a few trim clips and pull back a couple of covers on the left side of the trunk and you're in business.

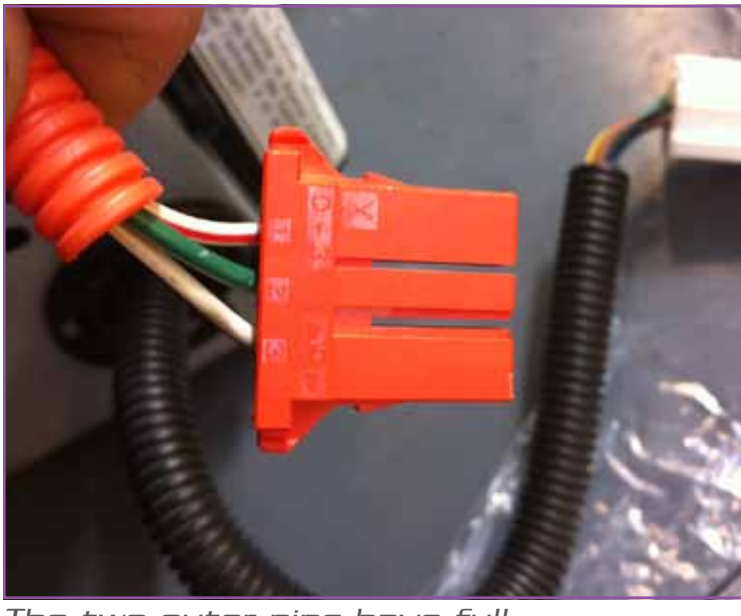
There is a small, easily-accessible connector on the left (driver's) side of the battery. I like to call it the "connector to nowhere" since it's plugged into a plastic holder on the side of the battery case. The two outer terminals (Terminal 1 and Terminal 3) have full battery voltage, and can be used to charge the battery without removing it from the car, bypassing or activating the System Main Relays, or performing any other jury rigging.

Once the cover has been pulled back, you'll be able to see the connector to nowhere and the interlock. ALWAYS remove the interlock before touching any orange (high voltage) components!

You may notice I'm holding the connector with my bare hand. This is because the battery service plug has been removed and I know it's safe. If the service plug were still in, there would be 274V at the connector. If I were to test for voltage using a couple of back-probe pins, and I touched them both with one hand, I'd probably lose a chunk of flesh, maybe even a whole finger. If I had one pin in each hand, I'd be dead. Yes, it is easy to kill yourself. So, always make the

The connector to nowhere can be pulled out for better access.

The connector holder is held in place with a push clip that can be removed using the service plug as a tool. One of the many clever ways the Toyota engineers try to keep us safe.

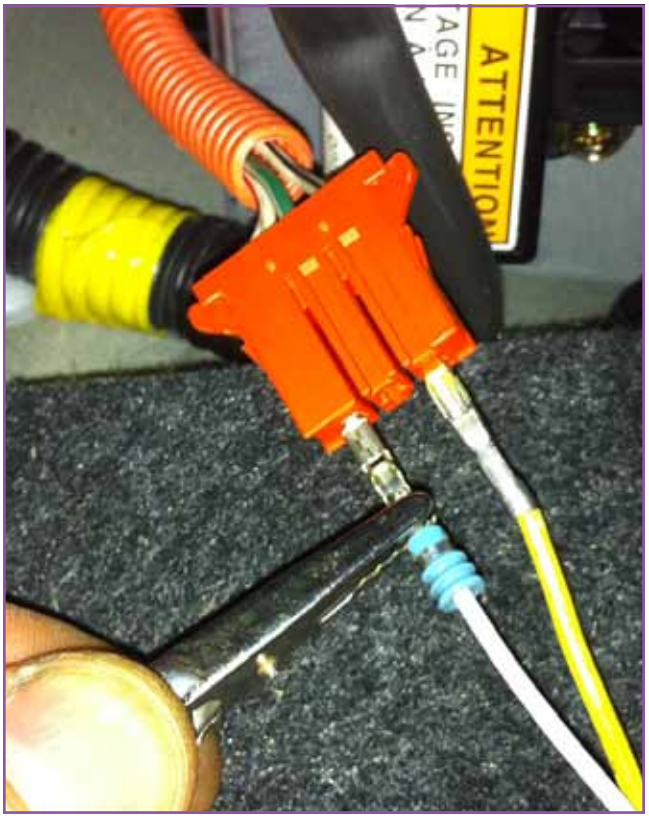


The two outer pins have full battery voltage and can be used to charge the battery.

service plug the FIRST thing you remove and the last thing you install. Remove the service plug, make your connections, put the service plug back and then do not touch anything until the charging is done and the service plug has been removed again.

Polarity is important. There is not a ready-made connector to plug in, so it is possible to hook it up backwards. I asked Gregory what would happen if polarity were reversed. He said, "The charger should recognize the reversed polarity and the relay shouldn't close. That said, I wouldn't recommend you test it." To find polarity, remove the service plug, connect your voltmeter to the two outer terminals, put the service plug back in, and take note of the reading. If the reading is negative, the red lead is on the negative terminal. If it's positive, the red lead is on the positive. Don't rely on the wire colors! The white/red has been negative and white/black positive in my experience so far, the opposite of what you might guess. Don't rely on my experience, though. Do your own testing.

When the reading is positive, the meter is hooked up correctly. Don't make the connection with a live circuit! Disconnect the service plug before connecting your meter, then plug it back in to take the reading.



Don't connect the alligator clips right next to each other. Leave plenty of space so they don't accidently short.

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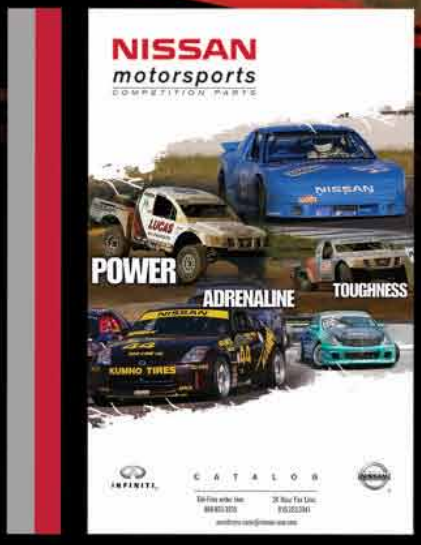

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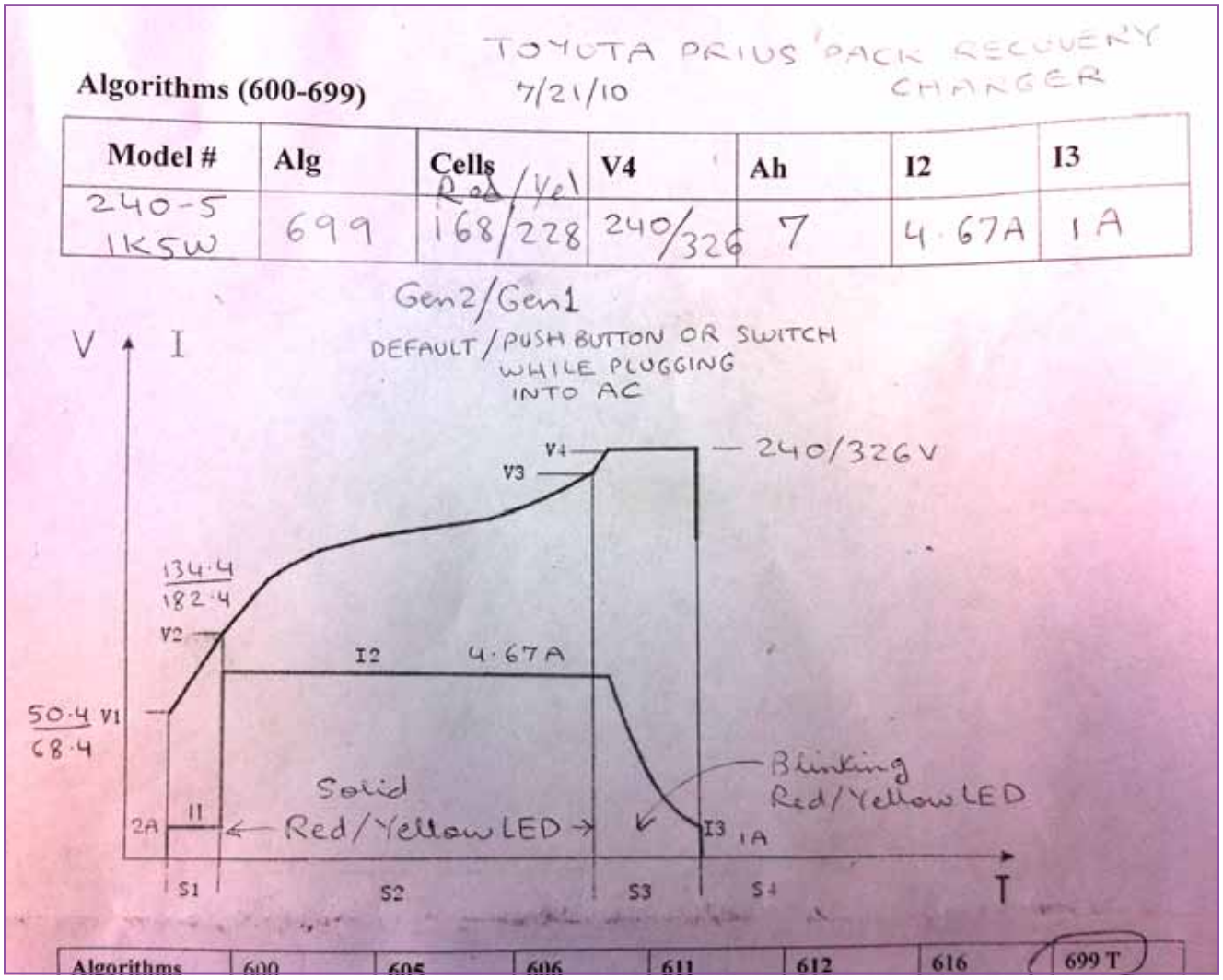
I use male blade connectors salvaged from old O2 sensor connectors to make the connection. It may seem really strange to be routing so much voltage through such tiny wires and connectors, but don't worry, they won't melt -- in fact they won't even get hot. Please don't touch the wires to test this, the insulation is not rated for high voltage and you could get hurt or killed. The combination of high voltage and low charging current keeps the voltage drop low, despite the tiny wires.

The charger defaults to the Gen2 algorithm when it's turned on. The reasoning is this: If you didn't read the instructions and started to charge a Gen2 with the Gen1 algorithm, you might damage the battery. To avoid this possibility, the charger defaults to the lower voltage. That way, there's less



A gradual rise in voltage pushes a steady current of 4.67A into the battery. The voltage eventually peaks at 326V and the charging current slows to about 1A. The charging cycle is time-limited to prevent damage.

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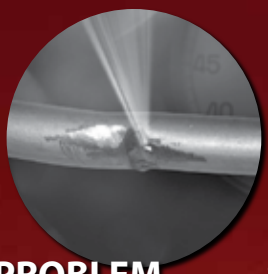

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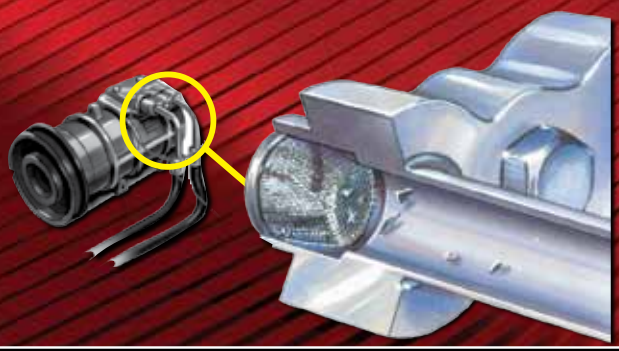

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risk of an incompetent user damaging a battery pack. If a Gen1 is charged with the lower voltage, it won't be hurt, it just won't charge fully.

To change the charging mode to Gen1, press and hold the select switch while turning on the charger. The change in algorithm will be verified by a change in LED color on the opposite side of the charger.

Use the switch to select the correct algorithm -- low voltage for Gen2 and Gen3, high voltage for Gen1.

The status indicator is used to indicate the algorithm selected. It's also used as a progress indicator during the charge.

So, how well does it work? Well, I'm still waiting for the official word after the data recordings are analyzed, but from what I can tell it works perfectly. According to Toyota's training material, the target SOC for the THS charger is 60%, the same as the target SOC while in the car. Take a look at the SOC in the data list below. I took this picture about two seconds after Readying the Prius following recharging with the ELCON charger. Pretty close to 60% SOC, no?

Now that the battery is charged, I figure I might as well test it, but this article is already too long. So, I won't include much detail on battery testing beyond saying that up to 1.2V is acceptable between "Battery Blck Min Voltage" and "Battery Blck Max Voltage." As you can see below, there is only 0.3V, so this battery is in perfect condition now that it's charged.

If you want to purchase your own charger, contact Gregory at:

ELCON / Electric Conversions
Distributor of Zivan Chargers
215 14th St.
Sacramento CA 95814
Phone: 916-441-4161
elcon@jps.net

Regenrative Brake Torq	0	Nm
Req Regene Brake Torq	0	Nm
Generator(MG1) Rev	4618	rpm
Generator(MG1) Torq	0.00	Nm
Request Power	0	W
Target Engine Revolution	1276	rpm
Engine Speed	1248	rpm
Master Cylinder Torq	0	Nm
SOC	59.97	%
Wout Control Power	20960	W
Win Control Power	-13600	W
Discharge Req to SOC	0	W
Drive Situation ID	3	

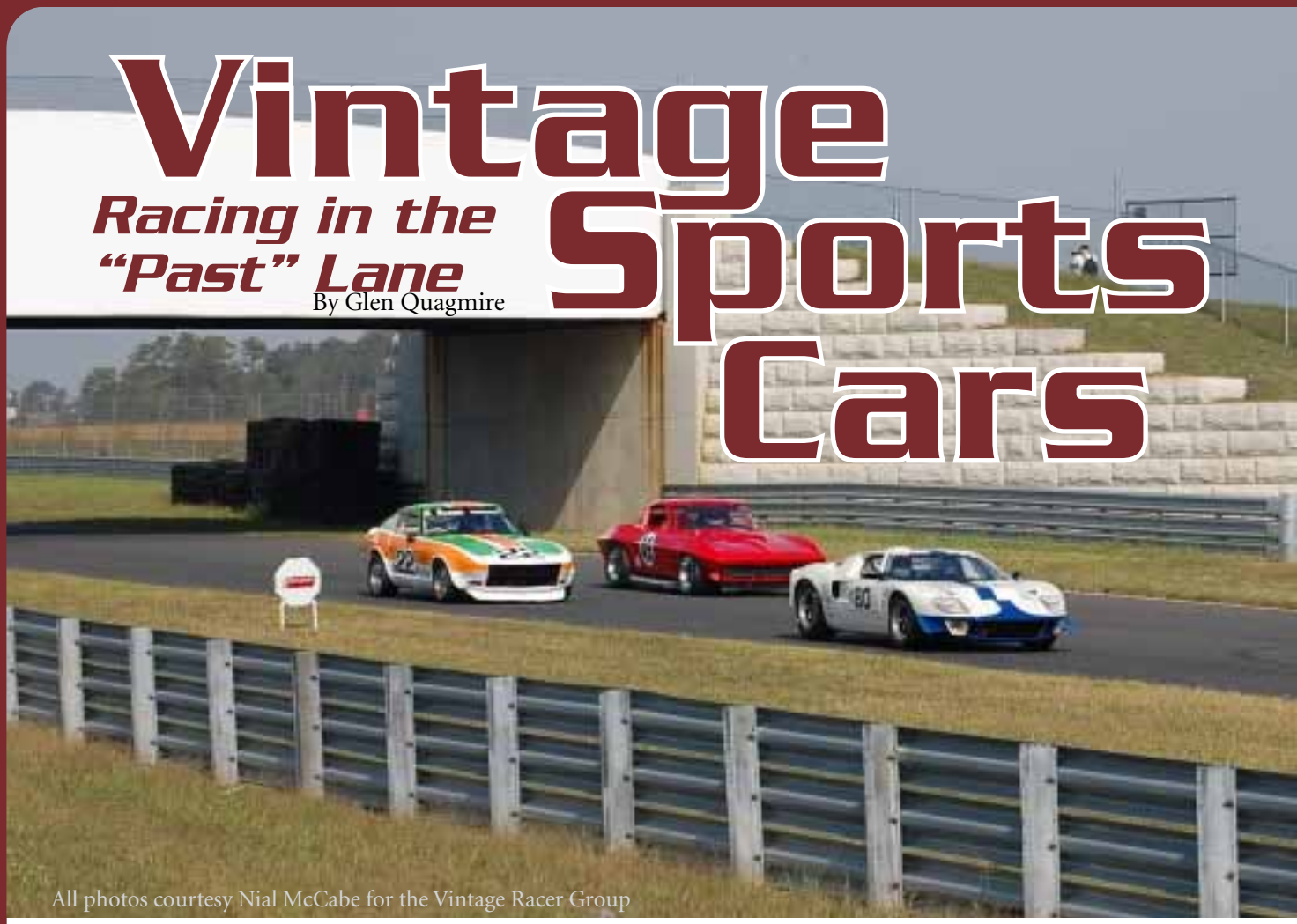
Hey, 59.97% SOC! Can't beat that!

A picture of perfect health!

Vintage Sports Cars

Racing in the "Past" Lane

By Glen Quagmire



All photos courtesy Nial McCabe for the Vintage Racer Group

As we all (thankfully…) get a little more "vintage," we seem to gravitate to the days and memories of our youth. And most of us "car guys" (and girls…) had at least some interest or involvement in some kind of auto racing "back in the day." For a lot of us it was going as spectators to the Friday night drag races. The more adventurous of us became participants. Others got involved in roundy-round racing, and learned very quickly not to open food or drink if we were sitting in the corners in order to avoid the "crunch" of food flavored with orange clay dust thrown up from the sideways race cars.

These days many of us follow NASCAR racing. We can follow cars, technology and the colorful personalities of the drivers and crew members from the comfort of our Barcoloungers. And the more dedicated NASCAR fans can join with, say, about a hundred thousand of their closest and most intimate friends and actually attend Sprint Cup®, Nationwide Series®, or Camping World Series® races at places like Dover, Chicagoland, or Talladega.

But what if you want to get closer to the action than your recliner? What options

are open to the Weekend Warrior? And is there a way to actually get your hands dirty in the process?

Happily the options are many.

Nostalgia drag racing has been, for some time now, a popular venue. Cars that raced decades ago have been, and continue to be, dragged out of dusty garages, refurbished or restored, had safety equipment updated, and returned to the ol' 1320 for a new life of competition.

Similarly, stockers, midgets, and others continue to be found, stripped down and rebuilt, and returned to their former glory, often in the colors and paint schemes in which they appeared when they were originally being actively campaigned. There's even a magazine dedicated to just these collectible and memorable cars, called Vintage Oval Racing.

But probably the most notable renaissance in the restoration, preservation, and campaigning of old race cars comes in the vintage sports car racing community. Over the last ten years or more, vintage sports car racing, on road courses, has grown dramatically in interest and participation.

The range of cars in this evolving sport is staggering – including everything from little British "bugeye" Sprites to former Formula 1 cars originally

campaigned by the biggest names in motorsports – names like Jackie Stewart and Graham Hill. While some of these folks are, sadly, no longer with us, many of the cars they drove still are. And they, like so many formerly-raced sports cars, are being found and brought back to safe racing specs, by privateers who have the resources, time and talent to restore them to their former glory.

Here's a quick run-down on the state of vintage sports car racing:

The Cars

Vintage sports car racing involves all sorts of interesting and varied cars. "Production" cars are race-prepared versions of cars originally built for street use. Think Corvette, Porsche, MG, Triumph, Austin-Healey, Alfa Romeo, Mustang, Camaro – pretty much anything built for the street. But don't expect to see a Dodge Viper or year-old Mustang in the mix; remember, we're talking vintage here.

Open-wheel ("formula") cars are of the style you'd picture in Indy 500 races – cigar-shaped bodies with wheels and suspension sticking out in the wind, unencumbered by fenders. These come in a variety of flavors, based on engine size from VW to V-8, and other factors like tire size needed to accommodate varying degrees of horsepower.

Sports racers are cars like Elva Couriers up to Chaparrals. Picture

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low, wide, flat, usually fiberglass bodies enclosing everything – wheels, tires, suspension, engines, etc. These may be 1 or 2-seaters, open or enclosed, again in different classes depending on drive trains and related enhancements. You may remember these types of cars from the original Can-Am series.

In all cases, since this is "vintage" racing, cars will be older, and can range from pre-war up through, generally, the 70s or so. Some will be high-end cars formerly raced by professionals, and some will be relatively simple, like the MGs, Austin-Healeys, and Triumphs mentioned above. Most sanctioning bodies will accept for competition cars that were not race cars in the day, but have been modified with period-correct parts and technologies. And, while it's been said that nothing's older than last year's race car, some vintage racing groups have established classes for reconstituted stock cars.

The Venues

Amazingly, despite urban sprawl and dramatic increases in real estate values over the last several decades, most race tracks that were around "back then" are still in operation and, in fact thriving. Legendary tracks all over the country host many vintage races each year, including the fabled Watkins Glen track in New York state, Road Atlanta in, well, Atlanta (suburbs, actually), the astonishingly long and fast Road America track in Elkhart Lake, Wisconsin, and (Mazda Raceway) Laguna Seca in California,

with its notorious "Corkscrew" downhill S-curve.

Motorsports in general, and vintage racing in particular, have become so popular in recent years that new road racing tracks have been built in places like the exciting New Jersey Motorsports Park in Millville, NJ.

Links to the various race tracks can be found in the web sites of the various sanctioning bodies listed below.

The Organizations

The Sportscar Vintage Racing Association (SVRA) is probably the biggest and best-known organization in the vintage racing community. They have rules that are recognized by most other sanctioning bodies, and conduct races all around the country. They welcome very high end cars of yesteryear as well as the more modest MGs and Triumphs.

The Vintage Racer Group (VRG) is a very active umbrella organization primarily in the northeast, and works with many other organizations in sponsoring races.

There are many other vintage racing entities, largely regional, around the country. Here's a quick run-down of some of the more active groups:

Sportscar Vintage Racing Association
www.svra.com

Vintage Racer Group www.vrgonline.org

Historic Sportscar Racing, Ltd.
www.hsrrace.com (primarily high-end cars)

Vintage Auto Racing Association
www.vararacing.com (west coast)

Vintage Sports Car Club of America
www.vscca.org (northeast; cars 1959 and older)

Historic Motor Sports Association
www.hmsausa.com (mostly southeast; high-end cars)

Historic Sportscar Racing - West
www.hsrwestrace.com (west coast, high-end cars)

Society of Vintage Racing Enthusiasts
www.sovren.org (Pacific northwest)

Vintage Sports Car Drivers Association
www.vscda.org (midwest)

Classic Sports Racing Group
www.csrgracing.org (west coast)

Vintage Drivers Club of America
www.vintagedrive.com (southeast)

And for our friends north of the border,

Vintage Auto Racing Association of Canada
www.varac.ca

So How Can I Be Involved?

Happily there are many ways a newcomer can get involved with vintage sports car racing. Many, but not all, vintage races are deemed "spectator" races and welcome on-lookers for a modest admission fee.

Many participants in vintage racing are doing so as "weekend warriors" themselves, and working on a limited budget with no formal pit crew and maybe just a friend or wife/girlfriend/boyfriend helping them. So if you can hook up with a racer there's a very good chance that they'd welcome your help as a pit crew member, and you'd have a chance to get your hands dirty while having a boatload (OK, OK, a carload...) of fun. And you can almost certainly connect with someone who lives near you who would welcome an extra pair of hands from time to time.

Furthermore, most vintage races rely heavily on volunteers and would be tickled to find a "car person" like you to be a pit marshal, registrar, help with timing and scoring, or even, with a little on-the-spot training, a corner worker or flagger.

And, finally, it's never too late to become a vintage racer yourself. It's not unusual to find drivers who continue to race into their 70's. Most of the above organizations have drivers' schools and, of course, there are professional high speed driving courses as well if your budget permits. You can rent race cars, and you can even buy a ready-to-drive (but not ready-to-win...) entry-level vintage race car for under $10,000 if that suits you. Bear in mind that, while your mechanical skills might allow you to build your own car to vintage standards, it's a universal truth that it's much cheaper to buy a car than to build one.

And, finally, no matter what your level of involvement, you'll find vintage sports car racing to be fascinating, memorable, very family-friendly and, most of all, fun.

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Small Businesses May See Some Relief in the New Health Care Act

by Mary Louisa L'Hommedieu, Esq.

The new Health Care Act will affect nearly every small business. The main provisions of the Act roll out over the next four years, with the major changes occurring in 2014. Most notably, beginning in 2014, businesses with more than 50 employees (or full-time equivalents) must provide affordable health insurance for their employees or face penalties. Businesses with fewer than 100 employees will be permitted to participate in insurance exchanges, to be set up in each state, where a pooling of resources should drive the costs of insurance down. And while small businesses are not required to offer insurance for their employees, the Act provides strong incentives for them to do so.

Until the Small Business Health Options Programs - or SHOP insurance exchanges become

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